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Passing of the World's Cataclysm

THE church bells tolled out the message at 4 o'clock. The armistice had been signed. A people had been freed. Once more the world could right about and face the future, where for a period of four years and three months and seventeen days it had looked backward into the past—looked backward to the depth of a thousand years!

We are again born. We have witnessed a new dawn of democracy, a new peace on earth, a new good will toward men. It means much. It means universal freedom and the right of people to pursue happiness, to the end that future generations may likewise freely pursue happiness. It means that. But most of all it means, and meant—this early sounding of the bells that morning—that God still sits on his throne, and that Christ again walks upon the earth. The War is over. Thank God for it!

The Hog Island Shipyard

LARGE organizations of successful record are growths. They have attained to bigness through a long, slow, upward building, and in doing so have but followed natural laws. There is such a thing as forced growth, however—hot-house plants, for instance. But these pay for their quick expansion in some way. Hot-house plants whose size has been forced are delicate. Likewise, any organization that has sprung up to giant proportions over night must, from the very law of things, be delicate somewhere.

Criticism has long been directed at Hog Island. Hog Island has failed to deliver ships according to initial promise. The critics say that. But the critics have overlooked something. It is the time-worn and truthful axiom that large bodies move slowly. Hog Island, because of her unnatural growth—a growth forced to complete fullness almost between suns—has yet to expand spiritually in keeping with her giant physique. Hog Island will yet prove herself. With all her departments co-ordinated, and with her gigantic personnel working in spiritual harmony with the needs of the "shell"—the physical properties of the plant—it is our prediction that the yard will turn out ships for the merchant marine in numbers befitting both her size and productive capacity.

To Revive Normal Trade Routes

IT was learned recently that the Shipping Board, as far as consistent with Government needs, is diverting ships to normal trade routes, and that within a few months officials hope to have American ships carrying needed commodities of peace to South and Central America, Asia and Africa, as well as to Europe.

Some ships requisitioned by the Shipping Board during the war are being turned back to private owners, and the Board plans to return such vessels as rapidly as possible. In all, about 2,500,000 tons of shipping was requisitioned.

In turning the vessels back, the Board, it was said, will not relinquish any of its rights to any vessel. The private companies will carry on the detail work of maintaining, manning and operating the ships, taking their cargoes at the direction of the Shipping Board and paying the wages fixed by the Board. Some members of the Board believe that at least two years must elapse before control of any of the requisitioned ships can be given up.

New York Port Improvements

OF the many improvements which must be made in the near future if the port of New York is to maintain all the advantages of its present supremacy, at least two stand forth as great crying needs, according to Murray Hulbert, Director of the Port and Commissioner of Docks. The first is the dredging of Ambrose Channel, and the second is the removal of the Red Hook Shoals menace, opposite South Brooklyn, by converting it into an island, with piers and warehouses. The commissioner stated that a grave injury is suffered by the port of New York as long as the Government fails to carry out the channel-widening programme. He declared that Philadelphia and other cities were taking advantage of setbacks here due to errors in the past and were doing their utmost to induce steamship companies to desert New York.

The agitation for the extension of a channel 2,000 feet wide right up to the mouth of the North River is important at this time principally because gigantic port and terminal improvements are under consideration here to meet peace-time conditions and a greatly expanded American maritime activity. With these better docking facilities carried out, however, New York city's transatlantic commerce could not be handled under the present hazardous conditions, where mammoth ships creep up the bay through a water lane not much wider than a creek. Commissioner Hulbert stated it as his belief that several of the largest ships afloat should have enough space at any point in Ambrose Channel to move toward the Battery two or three abreast, and in this we heartily concur.

Will Keep Up Shipbuilding

CHAIRMAN HURLEY, of the United States Shipping Board, repeats that every efficient shipyard in the United States will continue to have all the work it can do for many years, in spite of the ending of the war. The present programme calls for fifteen million tons of merchant ships. So far we have only completed about fifteen percent of this programme. Yet while the programme as a whole will be revised and designs for ships will be changed with particular reference to economical cost of operation, the continued need for building American-owned tonnage is obvious. Not only must we continue to supply our armies overseas and prepare to bring them home at the earliest moment compatible with safety, but Europe must be fed and supplied with the necessary

materials to permit the reconstruction of devastated areas. in order that both our friends and our enemies may become self-supporting and the burden of feeding the world be taken from our shoulders. There will be no abatement of shipping.

Want New York Free Port

SHIPPING problems in connection with after-war development in various fields of industrial activity were discussed at length at a recent meeting of the New York Board of Trade and Transportation, and committees submitted reports on various aspects of the transportation situation as it concerns the port of New York.

One report expressed approval of the recommendations of the United States Tariff Commission, extending the bonded warehouse system to include storage as at present, repacking and manipulating, manufacturing for export or domestic consumption, and in addition that the general bonded warehouses be permitted, where all or a portion of the floor space may be used for repacking, manipulation and manufacturing, for export or withdrawal, for domestic purposes upon payment of duty on the original imported merchandise. Also it was pointed out that free ports have been created and maintained in other countries and have resulted in vast benefits to the commerce and manufacture of those countries. The meeting closed with the recommendation of the After-War Organization Committee to the effect that the president of the Board appoint a committee to make a special study of conditions, and to report from time to time on advisable steps for the reorganization of matters pertaining to commerce and industry, both here and abroad.

Uniform Wage Rate for World Sailors

CHAIRMAN HURLEY, of the Shipping Board, now in Europe, plans to seek an international agreement between the governments, shipping interests and labor organizations of the principal maritime powers for standardization of seamen's wages and working conditions. Mr. Hurley expects to propose that the American laws and the agreements between the Government and the seamen's unions be accepted as the standards, and it is understood that the American Federation of Labor and the British Seamen's Union are prepared to support the proposal.

Such an agreement as that contemplated by Mr. Hurley, it seems obvious, would eliminate the chief difficulty that has confronted American shipping interests in past years in their attempts to operate in competition with other nations. The standards of American seamen are said to be the highest in the world; and now that this country is putting a great fleet of merchant ships on the seas, officials believe that unless some international agreement is reached a great proportion of trained seamen will be attracted to the American merchant marine.

Will Close Some Wooden Shipyards

IMPATIENT of the lack of progress and the inefficiency of a considerable number of shipyards engaged upon wooden ship construction, Shipping Board officials have agreed that upon the expiration of existing contracts no further contracts will be awarded for Government ship construction to those yards that demonstrated their inability to fill the Board's building requirements. This decision will be formally ratified at a conference presently between Chairman Hurley, of the Shipping Board; Charles M. Schwab, Director of Shipbuilding Operations; Vice-President Piez, of the Emergency Fleet Corporation, and other Shipping Board and Emergency Fleet Corporation officials.

It has been roughly estimated that between fifteen and twenty yards out of a total of more than 105 yards engaged in wooden ship construction will be affected by the Shipping Board's action. The inefficient yards are confined to no particular section, but are in all parts of the country.

In arriving at their decision virtually to close down inefficient wooden ship plants, Shipping Board officials hold that they already have spent enough time, money and attention upon the wooden shipyards to start them upon actual construction work; a large part of this time should have been spent in speeding up the construction of steel shipping. Notwithstanding, a number of yards, through inefficiency, sheer ignorance of the industry of building ships, and other causes, have made practically no progress, when comparison is made with the remarkable accomplishment of other yards throughout the country in the rapid construction of a merchant marine under the spur of war necessity.

This action of the Board is in line with the policy of that branch of the Government to take every possible step towards the ultimate object of maximum ship production.

Strainagraph Records Ship's Strains

A NEW device to record the "give" of a ship, very similar to the seismograph that makes an accurate record of an earthquake shock, has been developed by F. R. McMillan, research engineer of the Concrete Ship Section, and H. S. Loeffler, assistant research engineer of the section.

When equipped with this device, every strain that a ship experiences in a storm, or, for that matter, in any weather, is graphically recorded on a strip of paper which passes under the recording needle in the instrument. The apparatus was tried out on the concrete steamer *Faith* on her first voyage.

The strainagraph is built somewhat on the principle of the seismograph and the numerous devices used by doctors to record pulsebeats and other movements peculiar to the human machinery. It may be destined to play an important part in future ship designing, since it gives a simple medium for comparison of the relative strength of different types of ships. These instruments, placed in different parts of a ship, by showing weakness in these locations, give the expert a workable chart upon which to build an analysis of a ship's seaworthiness.

IMPORTANT NOTICE

Due to Government restriction on paper, it has become necessary for MARINE ENGINEERING to discontinue immediately at expiration date all subscriptions for which cash has not been received for renewal.

We regret very much the necessity for this action, as heretofore we have always allowed 90 days' grace.

Our subscribers are urged to send remittance for the renewal of their subscriptions as soon as notice of expiration is received. If the subscription is allowed to lapse it will be impossible for us to furnish back numbers and our subscribers' files will be broken.

Fig. 1.—Typical Inland River City with Steep Bank, Showing Terminal Possibilities

Handling Freight on Inland Waterways

Advantages of Effective Inland Terminals—Operating Costs Small—Importance of Mechanical Methods

BY H. MCL. HARDING*

MANY of the smaller communities along the inland rivers could now take advantage of the saving effected by river transportation, as the larger cities are doing, were they provided with correctly designed and equipped terminals. The expense of installing permanent terminals, such as would give capacity and speed of transference, economy of operation and facility for handling all kinds of material and package freight, has in the past required too great an investment for many of the smaller towns. By utilizing present engineering plans and designs, however, and adapting standard hoisting and conveying machinery with movable cross-tracks, the cost of investment in a terminal which would fulfill all conditions for river traffic for the smaller towns has now been so reduced as to come within the financial possibilities of very small communities. This has been made possible not by new appliances but by the adaptation of standard machinery in accordance with correct terminal principles.

As is well known, the terminal operating expenses upon unimproved river banks are so great as to nullify the advantage of the lower rates of water over rail transportation. This is especially true of those towns and villages which have high river banks. The transference of freight between the river and the top of the bank has accordingly been one of the serious problems to be overcome.

For the successful operation of terminals at the smaller towns and villages—terminals which will give the requisite capacity and economical operation—the following requirements are essential:

A village can only make a small initial investment, as the quantity of freight may not be great and often the resources available are not large. The operating costs must therefore be small. Saving of manual labor on the barge and in the terminal operations on shore is essential. In some way the drag up the steep bank must be eliminated, and the rehandling movements—as from the top of the slope into the shed—reduced to a minimum. Furthermore, barges must not be detained any longer at the terminal than the shortest time necessary to discharge and load the freight, to say nothing of the fact that there should be a possibility of increasing the capacity of the terminal without effecting any change in that portion already installed.

A shed for the protection of freight against inclement weather and thefts, the same as a railway freight station,

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Fig. 2.—Showing the Elevation of the Upper Level of the Bank from Opposite Shore

should be built. Since much of the freight is through freight, co-ordination is required between water and rail, and it must be possible to lift and swing the freight directly from the car to barge or from barge to car. Likewise, the cars should be already in place on top of the bank to avoid the usual waiting for the locomotive or the drilling engine to move or place the cars, as is the case when car inclines are used in the equipment of a terminal. Another thing, the placement tracks should be controlled by the terminal authorities, although at the beginning of the terminal operations those tracks existing and belonging to the railroads could be utilized. The railway companies, according to federal law, will make railway connections with the river terminals.

If provision is made for the condition mentioned, then small river communities can have the same advantages as large cities, and likewise have a proportional reduction in the cost of the shipping and receiving of freight.

Need for Adopting Mechanical Methods

To secure these results the following mechanical methods should be employed. The operations of hoisting freight to the required elevation and of conveying and depositing it on the top of the bank, within the door of the box car or directly upon the open car, or upon the river quay, or upon drays on the quay, or in any part of the freight shed, should be performed rapidly, continuously and directly, without delay or congestion and without rehandling. All of this work should be done by machinery, thereby effecting a great saving in man or horse power; and if these operations are so handled at a well-planned terminal, the height of the bank will be no obstacle, and the distance to be covered in conveying freight into the shed and to the rear of the shed by machinery presents no difficulties.

Electricity should be used as power, which may be obtained from the nearest power plant. This power is always available by turning on a switch, and the electric light enables the terminal work to be continued day and night without cessation. Furthermore, when the barge arrives it should not be necessary to hunt up a gang of roustabouts to move the freight. One man per train at the terminal with modern equipment can do the hoisting, conveying, lowering and depositing. No wharf boat with its upkeep and operating expenses would be required. The usual manual labor of handling from barge to boat, rehandling from boat to dray, followed by the long, hard, horse-killing climb to the top of the bank, would be eliminated.

Difficulties Met With Formerly

In cases where merchandise inclines or elevating platforms have been installed, the freight must be first placed upon the incline. When the freight reaches the top it must be rehandled from incline or platform to dray, car, quay or shed. To do this manual labor a number of men must be quickly available, and often they must be kept under continuous pay. At the present time there is great difficulty in obtaining freight handlers even at high wages. The installation, therefore, of mechanical appliances and more progressive methods of operation is absolutely essential. The first step is to erect on the bank at least two wooden frames, one at the water's edge and the second frame about twenty feet inward. Upon the inner sides of these frames there are supported big wooden stringers upon which are placed T-rails, although steel I-beams may be substituted for these wooden stringers. These stringers, with movable cross-tracks, later described, extend from above the barge to within the shed, and their height should be the same as high river bridges, in order to avoid any possible interference by river craft. Railway tracks for co-ordination may be installed in front and, when desired, to the rear of the shed.

The vertical piles used as supports at the water's edge need not interfere with the flow of the river during flood water. Where necessary, they may be protected by pile clusters against ice or driftwood coming down the river.

Fig. 3.—Interior of Terminal Shed, Showing Overhead Tracks

The banks should be protected against erosion from any cause by a row of piles close to the water's edge and riprap or rough paving placed on the face of the bank. Fender piles should be provided along the river against which, at varying levels of the water, the barges can lie. The varying levels of the river do not affect the operation of the terminal—merely a few feet more or less of hoisting are needed in accommodation.

Before work is begun for any new installation, even though it be of the simplest type, a thorough engineering report should be made and plans formulated, as a measure of insurance that the whole terminal be designed, laid out and constructed according to modern terminal principles.

The distance of thirty feet or more between the parallel stringers and T-rails may be spanned by one of two travel-

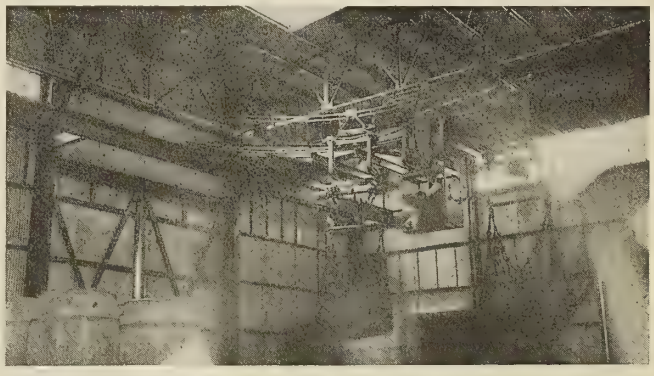


Fig. 4.—Tractor and Trailer Hoists with Nets

ing crane bridges of standard design. These bridges are like cross-traveling shop cranes, with the exception that, instead of only the traversing movement of the hoist from one side of the crane to the other, the freight conveying and hoisting machinery will pass along one of the T-rails, and from there upon the movable cross rail or track, and finally along the other side and cross rail to the starting point. Thus the tracks will admit of a complete adjustable loop.

The bridges of the cranes support the cross or movable tracks. These tracks have sliding connections with the side tracks, or with the cross tracks, or from the cross tracks to the side tracks at any place. There is formed,

therefore, a movable, adjustable loop from which every cubic foot of space between can be served. Accordingly, freight can be lifted from or placed upon the barge or any square foot of the quay or shed. Also, it may be placed upon any carrier. In addition, the freight can be distributed and tiered to a height three times that which is customary when only man power is used. Only a portion of the barge capacity is usually reserved for the smaller terminals. However, if a whole barge is to be discharged or loaded, the barge can be placed longitudinally and the usual apparatus utilized. Bulk material—coal, sand or rock—or miscellaneous merchandise, as package freight, may be transferred with equal facility to the designated coarse freight space, often at the rear of the shed.

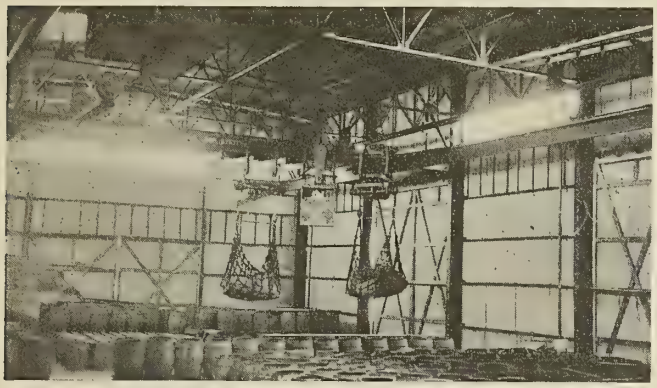


Fig. 5.—Arrangement of Overhead Cranes

A conveyor train, which consists of a tractor corresponding to a locomotive, and with one to four hoists, lifts the drafts of freight by electricity. The tractor has power to draw four carrying hoists. Each electric hoist has a capacity of 100 feet per minute with a load of two tons. The operation of these hoists, whether four or one, is controlled by the one operator in the tractor, who also moves the bridges, which will be described later, to the desired positions. The tractor and hoists are equipped with brakes and safety limits.

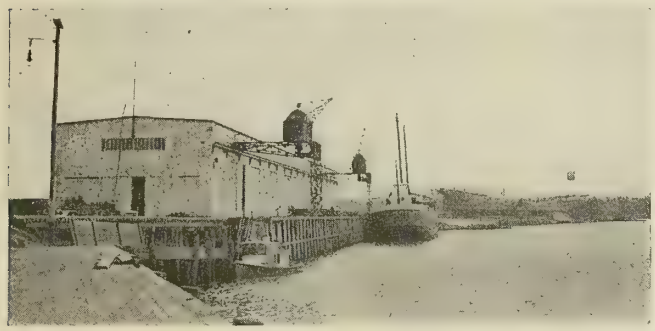


Fig. 6.—Concrete Quay with Oak Protected Wall

The number of hoists in a train, as well as the number of trains at a terminal, may be determined by using the maximum tonnage of the freight, either outbound or inbound, as a basis. One tractor and one or two carrying hoists may be first installed; other hoists or other trains may be added as needed without effecting changes in the original installation, or interruption in the service.

Two bridges are usually installed, since far better results are thus obtained. The initial increase in cost resulting from double installation is by no means commensurate with the advantage gained. Where only one bridge is installed, a loop should be placed at the barge end and each bridge equipped with an electric motor for traveling on the side tracks, as is used for a traveling shop crane.

For the smaller terminals, to reduce the size of the ground area covered, the shed should be made about 30 feet in height and with surface dimensions of 40 feet by 45 feet. This length of 45 feet may easily be extended as far as desired and yet be served by the same machinery. A warehouse for long storage is placed preferably to the rear of the shed. Freight may be taken from the barge to the warehouse by the same machinery which is used to locate it within the shed.

Method of Operating Tunnel

To understand the method of operation fully, the photographs accompanying this article, showing the machinery as installed, should be carefully noted. As soon as a loaded barge comes alongside the quay, the first bridge, with its movable cross track, is moved out over the barge as far as may be required. The hooks of the traveling hoists which have passed out on the cross tracks over the barge are attached to the freight, which is lifted vertically by the electric hoist above the elevation of the top of the bank. Either one or four loads per train are conveyed to the designated place, the movement generally corresponding to the direction of the hands of a watch.

The second bridge, with its movable cross track, is placed either over the open quay space or over or alongside the car tracks. It may also be placed in the shed; over the open space to the rear of the shed; or at the warehouse. Upon this second bridge the tractor travels in its return, the hoist depositing one load and then returning for another.

If there are four hoists, eight or more tons may be conveyed in one trip. Meantime, if there is sufficient freight, two or more trains may also be raising their load and conveying it while the other operation is in progress. A great increase of capacity may be provided at any time by adding trains to operate on the existing loops. It should be remembered also that in many instances the train in its return to the barge can be carrying outgoing freight.

As has been mentioned before, the number of trains needed and the number of hoists per train will depend upon the volume of freight to be discharged and loaded. To avoid delays it has been found advantageous to leave slings in place about the freight and to shift small packages in nets. Everything is then ready for attaching the hoist hooks.

As a distance of one hundred feet more or less in the conveying makes little difference in the cost or time of transference, the speed of traveling with full load being 350 feet per minute, the tracks and shed may be placed sufficiently far back to be upon the elevation of the top of the bank. Consequently filling or quay-wall construction may not in all cases be necessary.

Modifications Required for Special Conditions

For especially heavy weights, above four thousand pounds, two hoists should be attached, which would furnish a lifting capacity of eight thousand pounds. Hoists of greater capacity can be furnished, but experience has shown that a hoist with four thousand pounds lifting capacity is preferable. The spans of the traveling bridges may be made greater if necessary. Spans of fifty feet or more are often installed.

In some cases two sets of parallel tracks are placed side by side with bridges and movable tracks. In this case great transferring capacity is provided, especially when there are several trains for each set of tracks. Two side tracks, the movable cross tracks, tractor and hoists and

shed and surface railway tracks may be considered as constituting a workable, income-producing terminal unit.

The installation which has been outlined here was especially designed to provide smaller communities with mechanical appliances at low initial cost; to secure the greatest speed in discharging and loading barges, and to accomplish the direct raising of the load from the barge to the top of the bank without the usual expensive handling and rehandling. With the equipment mentioned, freight may be immediately placed upon the upper elevation without manual labor; upon the cars; at the door of the cars; upon the drays. As previously mentioned, it may even be taken into the shed and there tiered; or to the areas behind the shed; or to the warehouse, if one is erected. These operations are accomplished rapidly by a continuous succession of wholly mechanical movements

Other possibilities for the use of this equipment will commend themselves to the practical river man. For example, levels lower than the top of the bank, either just above the low level of the river or a third or half way up the bank, may be utilized, in many cases to hasten the discharging or loading, so that the barge may be detained for the least possible time. The loads from the barges may be placed upon these lower levels by the hoisting and movable track machinery, and then, after the barge has departed, be taken by the same machinery to the top of the bank and distributed.

Handling Freight for Early Transshipment

As often happens, a large barge may have freight for early transshipment to smaller boats or barges operating on tributary streams or serving nearby factories. Such freight can be taken from the barge by the overhead hoists, placed on this lower level by the tractors and hoists, and afterwards, by the same machinery, lifted from this low level and placed onto smaller boats, barges or flats for further transportation. Should it be desirable for a portion of this freight to be lifted to the higher level for railway car or dray loading, or to place it in the shed for local transportation, this can be done at any time by the same machinery. Should there be a rise in the water level, loading and unloading can go on as usual.

It is fundamentally necessary to serve area and not lines. If freight be placed only beneath an overhead line track, then it is necessary to have many such tracks, gridironing as it were the area with many overhead tracks and switches. This installation is exceedingly expensive and will require many men to remove the freight from a point directly below the track to permit a second load to be deposited there, or to buttress freight already tiered. The apparatus is very simple to operate. There are no switches in the tracks to be opened or closed, and there are only two side tracks attached to the side posts and to the side columns of the shed. The expense for similar spans and capacity is about the same as for the indispensable shop cranes. The freight may be placed over any square inch of the quay or of the shed floor, and there can be a continual succession of movements without any necessary delay or interference of trains. These, it should be noted, can travel in either direction. The system as described—a combination of the familiar traveling shop cranes, seen in every machine shop, together with the more flexible monorail—will fulfill all the exacting conditions of freight handling and transference at inland river terminals. It provides the area serving advantages of the shop crane as well as the flexibility as to curves, distances and speeds of service of the monorail.

These mechanical appliances, especially adapted to inland river freight transferrence from water to shore, can be installed at the lowest first cost proportional to the results obtained, and can be as rapidly and economically operated, thus removing the objections to high banks and securing the fullest co-ordination between barge and railway car.

At the larger city terminals, when all available land is necessary for the terminal and a large tonnage of freight is to be transferred, the whole area, including the levee, should be utilized. The quay wall and an operating combination of the traveling gentry crane and the adjustable loop system could here be employed to advantage.

Sectioning Great Lakes Ships for Transportation Through Welland Canal

Great Lakes vessels of 6,000 tons and over are cut into sections before they can be brought through the Welland Canal to the St. Lawrence River. One hundred and twelve vessels have reached the ocean by this route during the year. Before the river freezes this total will probably reach 180.

Formerly the use of a dry dock on the Lakes for cutting and another one in the St. Lawrence River for rejoining the vessels was necessary. Last fall, when the need of ships was very pressing, Chairman Edward N. Hurley, of the United States Shipping Board, desired to move as many vessels from the Great Lakes as possible. The board could commandeer any number of vessels desired. Dry docks on the Lakes were sufficient to get a number of boats through, but only two dry docks were available in the St. Lawrence. These were already occupied by ships. Engineers of United States Shipping Board determined to put the halves together while the parts still floated in the St. Lawrence. Twelve were thus put together; four others in drydock, and five ships which were small enough to pass through the canal intact—twenty-one in all were sent out to the Atlantic. The steamers were refitted and strengthened at Atlantic ports to fit them for ocean service.

Details of Sectioning and Rejoining

This year twelve more old ships have been requisitioned and refitted on the Lakes. All of these vessels had to be sectioned and rejoined in the St. Lawrence. The details of the operation as it is accomplished without waste are as follows: Temporary frames of 6 by 6-inch angles are placed around both sections of the ship at the point where she is cut, in such a way that they can be drawn closely together when the ship is rejoined. These angles are bored for 2-inch fitted bolts. The plates of the shell, tank top and decks that do not butt on the special frames are taken off and, where necessary, light patch plates are added to support the special angle frames. When the two sections of the ship are floated together, the ends are trimmed by water ballast until they come together as nearly evenly as possible. Final adjustment is then made by driving drift pins in the 2-inch holes in the special frames. Fitted bolts are then inserted and the ship is thus held firmly together. The plates that have been removed are then put on and riveted. When work above the water line is completed the ship is put in dry dock so that the bottom plates may be put on. Finally, the temporary joining frames are taken out and temporary bulkheads removed. Some of the reconstructed ships need no temporary steel bulkheads. In some cases, however, where the bow section is short, it is necessary to use one temporary wooden bulkhead. Much dry-dock time is saved by this procedure, as compared with the old method of floating the two pieces in dry dock and bringing them together with heavy tackle.

Shipbuilding Costs and Estimates—II*

Careful Reading of Specifications Necessary—Must Have System—List of Items—How to Deal with Individual Items

BY JAMES M. ROBERTSON

INQUIRIES for prices of ships reach a shipbuilder in all forms and from all quarters. Some give the most meager particulars, others are more or less elaborate in detail, while a smaller number of inquiries may require that specifications and plans be submitted with the price, and considerable time and labor will be spent in this direction before the estimate is made.

Estimating to be satisfactorily carried out must be done systematically; otherwise the best results will not be forthcoming. The first step is to glance over the specification and plans to obtain a general idea of the type of vessel, and while so doing to mark off the items which bear on the engineer's part of the work. Most hull specifications contain paragraphs affecting the engineer's estimate of the cost as laid down in the usual demarcation of work between those departments, and the engineers' estimator should be notified at once of these. In the same way the hull estimator usually receives extracts from the engine specification relating to items allowed for in the ship's estimate.

In an important estimate, prices or rates are generally asked from sub-contractors for the more important items of ships' outfit and deck machinery, such as anchors and cables, upholstery, cooking gear, winches, windlass, steering gear, etc. Many of these fittings are specified by shipowners to be supplied by particular makers, so it is safer to ascertain these firms' current prices.

The specification is then read through slowly in conjunction with the plans, and brief notes are made on the estimate sheet of the nature and extent of material to be covered. This part of the work cannot be done too carefully, and the utmost pains must be taken to understand and assimilate what is being read so that no important item is overlooked or omitted.

The technical sheet gives concisely the leading particulars of the proposal under consideration. It is most important, and if carefully filled in enables anyone to obtain at a glance practically all the information considered necessary by a technical man. It forms a very handy reference, and might be used, if necessary, as a basis for making plans and specification of a new vessel or of entirely recasting a proposal.

Steel Work

The steel weight is a very important factor in an estimate, and various methods are in operation for estimating and checking these figures. The following may be mentioned:

Calculating in Detail or Solid Principle.—This method is not the most rapid, but by some it is considered the only system by which correct results can be hoped for, having regard to the constant evolution of ship design.

By coefficient.—Length × breadth × depth × coefficient (say .3 to .4)

100

+ Length of erection × breadth × 8 × coefficient (say .1 to .2)

100

+ Weight to cover owner's requirements over classification rules

= Total estimated steel weight.

Use of Curves.—This method is valuable for checking purposes and rough approximate estimates, and is more generally used in these ways, as it is not considered to be sufficiently accurate in itself for important estimates.

Comparative estimating from a vessel already built is a most reliable and quick method for arriving at the steel weight of a typical vessel.

The most suitable basis available, especially as regards breadth and depth, is ascertained, and additions and deductions are made on the basis total to correct differences in arrangement, scantlings, dimensions and fineness between the basis ship and the proposed new vessel.

Stem, Sternpost, Propeller Brackets and Rudder.—Weights are generally based on classification rules for type of vessel under consideration. Particular care must be taken to calculate on the material specified and to cover in the rates per hundredweight any rabbeting, scarphing, bushing and royalties required in connection with these items.

Rivets and Ironworkers' Labor

Rivets.—Weight averages about 5 percent of steel, except in oil vessels, where it is fully 6 percent.

Ironworkers' Labor.—This is calculated on a rate per ton of steel weight, or on the cube and erection numeral. Curves are often plotted on each of the above bases, and values ascertained therefrom. In other instances values may be built up from comparisons with suitable basis ships as to decks, bulkheads, erections and scantlings. Experience and good basis costs are the main factors in securing good results.

The two most common methods of approximating carpenters' timber are as follows:

1. *Add and Deduct Principle.*—Here a suitable basis boat is taken and prices brought to date. Quantities of different timbers in cubic feet are dealt with, and additions or deductions are made to correct differences between the basis and the proposal. Suitable percentages to cover for waste are added to the additional quantities, and these are then priced out at current rates. Sundry items are usually assumed common to both vessels.

2. *Calculating in Detail.*—Decks, ceilings, sparring, hatches, derricks and bulkheading are all measured from the plan as specified, and after allowances are added varying from 10 percent on decks to 40 percent or 50 percent on awning or boat gears to cover waste in cutting up, the quantities are priced out at rates per square or per cubic feet of sawn timber ready for use.

Timber and Joinery Work

Joiners' Timber.—In a cargo vessel it is customary either to measure up the floor area of the different living spaces and price these at rates per square foot taken from a suitable basis boat, to cover timber, stores and labor, or to run the whole out at rates per room for officers and per man for crew; thereafter in both cases to add suitable amounts for stores, ladders and engine and deck fittings.

In a passenger vessel, however, the pricing of joinery work becomes an arduous undertaking, as, in an important estimate, all the framing, divisions and lining in different classes of accommodation may require to be measured up, and average lineal dimensions obtained for each class of room. These are priced out at suitable rates

* Abstract of a paper read before the Greenock Society of Shipbuilders and Engineers.

per lineal foot, and each item of furniture is valued separately, and a rate per stateroom of each type arrived at. Areas of ceilings and walls of public rooms are also measured up, and priced out at rates based on past results. Floor-area rates, or rates per room for officers, and per man for crew, all calculated from a suitable basis, are used in arriving at the cost of accommodation for the ship's company. All other work, such as galleys, pantries, ice-houses, ladders, storerooms, electric light, casings, casing insulation and deck fittings, are dealt with individually according to specified requirements and based on suitable past records of similar work done.

PAINTING

It is very difficult to estimate painting with any degree of accuracy, as conditions are never twice the same.

The hull proper, which practically includes all work to weather deck, is rated from the steel weight or on the cube and erection numeral for material and wages.

Accommodation.—These are rated per $5.00 value of joinerwork, or priced out at a rate per room.

Bottom Composition.—Usually a rate per square foot on the hull surface.

Cement Work.—Weight is arrived at from suitable coefficient on the square numeral. Wages are based on rate per ton.

Smithwork.—No waste is here allowed on davits.

Plumber Work.—The cost of the wastes in connection with the sanitary fittings is usually arrived at by counting up the number of separate wastes required on the basis of one for each fitting or set of fittings, pricing them out at rates per place for material and wages on past records of work done.

ELECTRICAL WORK AND CANVAS GEAR

Electrical Work.—In a cargo vessel cost is usually found by counting the number of 16 candle-power lights to be fitted. A rate per light is taken to cover installation. Rate per bell-push and any sundry special items are allowed for separately. Plant is allowed according to requirements based on past records for similar work.

In a passenger vessel inquiries are usually sent out to electric light firms for prices and the most suitable used, or an estimate may be built up in detail from past cost records according to specified requirements.

Canvas Gear.—Area to be covered is measured up and rates per square foot fitted area taken for awnings and tarpaulins. Sails and covers as specified.

Rigging gear, sheet iron, mechanics' work and outfit are all dealt with systematically according to specification, past cost results for similar work and present prices.

The value of scrap (8 to 10 percent of steel weight) is usually deducted from the estimated cost of material.

Employers' liability and National Health Insurance (in those countries which carry this type of insurance) are sometimes included under materials instead of being debited to charges. If so, the amount is estimated as a percentage (usually 2 to 2½ percent) on the total wages.

Finished estimates should be rough checked from curves of actual vessel costs plotted on the cube and erection numeral, as a precaution against serious omissions.

Tender.—The main items which the tender will set forth are briefly as follows: The dimensions of the proposed vessel, speed, the estimated time for completion, price, particulars as to instalment payments and guarantees against defects, any modifications of, or exceptions taken to, specification. Conditions of contract will also be enclosed which will include protective clauses relating to strikes, lock-outs, fire and bad weather, and extension of time for such delays. In a word, all things should be considered.

The Rivetless Steel Ship

The building of a steel ship in three-quarters of the time and at three-fourths the cost heretofore necessary is the latest revolution promised in the sphere of shipbuilding. Instead of the present method of riveting, experiments indicate that steel ships can be entirely put together by electric welding. The Electrical Welding Committee of the United States Shipping Board Emergency Fleet Corporation has formally urged that a 9,300 deadweight ton ship be built by this process. The general sentiment among the body of experts, however, recommends that a smaller ship first be constructed. Meanwhile, a 42-foot electrically welded midship section of a 9,600-ton ship is about to be built for demonstration purposes at the yard of the Federal Shipbuilding Corporation at Kearney, N. J. The methods of assembling and welding to be used are due to A. J. Mason, consulting engineer for the United States Shipping Board.

Smaller electrically welded vessels already in operation and giving good service establish the practicability of the principle. When in June, 1918, England launched a 275-ton barge which was constructed wholly by electric welding, the claim was made that this was the first electrically welded boat ever built. America also claims credit for the first vessel put together by electric welding. Several years ago Mr. Geary, of the Geary Boiler Works, at Ashtabula, Ohio, built a 60-foot tug by the welding process. It has since been in satisfactory service on the Great Lakes. The Electric Welding Committee believes that this boat was the first electrically welded vessel of any size built anywhere in the world. The English barge has also shown good results. It has crossed the channel several times in stormy weather and has given no evidence of leakage. In fact, so successful has it proved that England is now building a 1,000-ton power ship largely by electrical welding.

Electric welding presents certain definite advantages. In a 5,000-ton ship about 450,000 rivets are used; a 9,500 deadweight ton ship requires 600,000 or 700,000 rivets. By the welding process the saving in labor on the minor parts of a ship is reckoned at from 60 to 70 percent. On the hull plating and other vital parts the saving in labor, cost and time of construction is conservatively placed at 25 percent. Moreover, welding means a saving in weight. The weight of rivets on the hull of a 9,500-ton ship would be 500 tons. This weight eliminated, the ship could carry 500 tons more cargo. These estimates are offered by the Electric Welding Committee, of which Professor Comfort A. Adams is chairman.

Mississippi Barge Line

A fair trial of the possibilities of a barge service on the Mississippi River is being made by the Government. The system has already been inaugurated with bi-monthly arrivals and departures between St. Louis and New Orleans.

The once untamed Mississippi, whose reduction to a lighted, patrolled, docile stream Mark Twain commented. now has a federal manager. Last year the Committee on Inland Water Transportation made the preliminary arrangements for the movement of freight on the river. The United States Shipping Board has assisted materially in providing transport, the railroads are ready to co-operate and not obstruct, and now, if ever, the Mississippi should prove its usefulness as a highway.

Two of the three barges are carrying the equivalent of sixty freight cars of grain, and the third carried a mixed cargo on its initial trip. Taking it as a whole, the barge line will be a decided success.

WOODEN TOWBOAT FOR ERIE BASIN TOWING AND HOISTING COMPANY

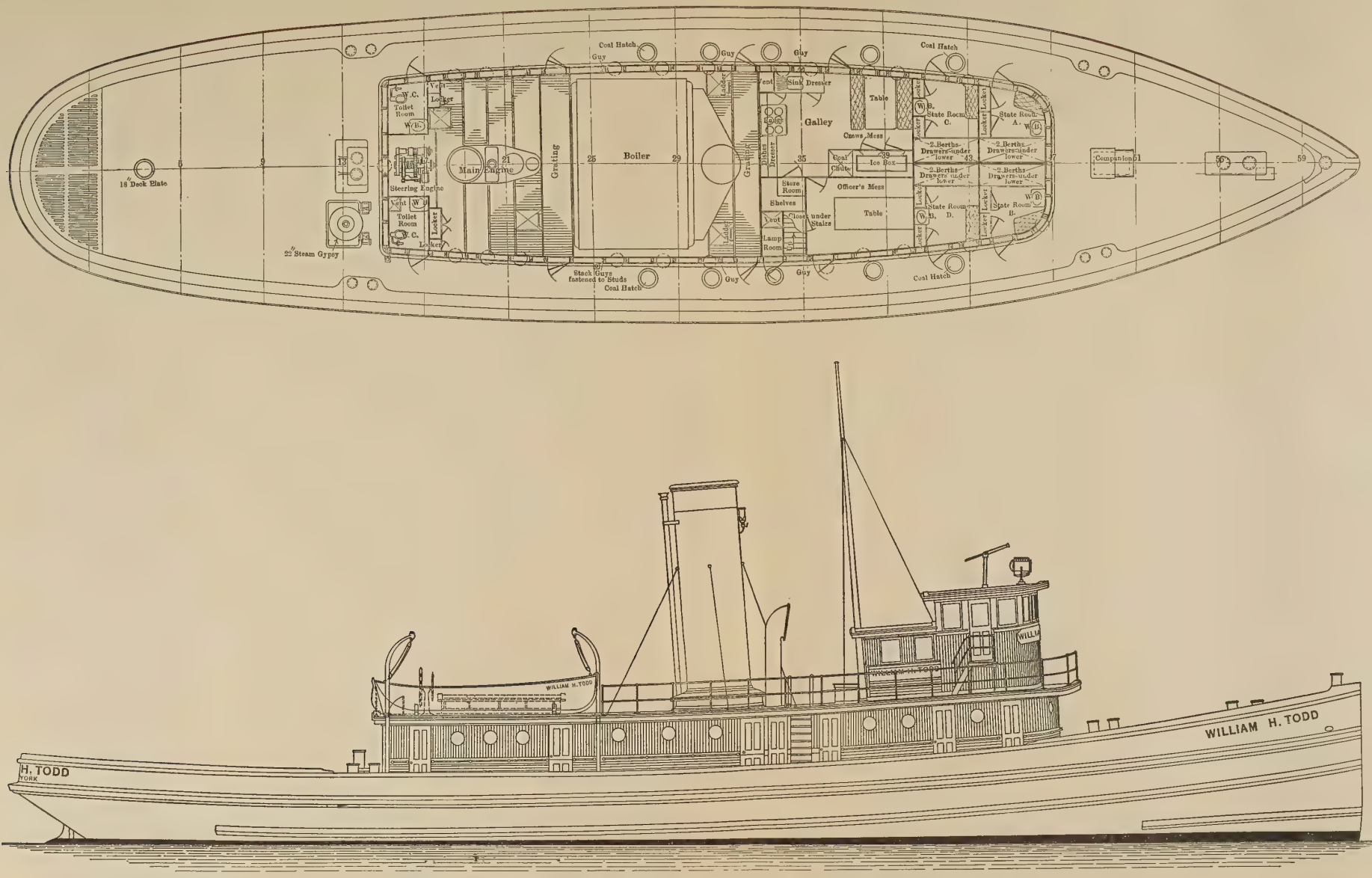


Fig. 2.—Length Overall, 129 Feet 0 Inches; Beam, Outside of Planking, 28 Feet 1 Inch; Load Draft, 12 Feet 0 Inches

Designed by Gielow and Orr, Naval Architects, New York

Plans and Specifications of New Wood Tow Boats

Built for Hard Service—Compound Engine of 750 Horsepower—Scotch Boiler with Three Morrison Furnaces

THE two tugs, *James Dougherty* and *William H. Todd,* now being built for the Todd Shipyards Corporation, of New York, from plans and specifications prepared by Gielow & Orr, will soon be added to the tow boat fleet operating along the Atlantic seaboard. These tugs are being constructed of wood, heavily built throughout, to meet and withstand the hard work required in the tow boat service. From looking over the principal dimensions—length overall, 129 feet; length between perpendiculars, 116 feet 8 inches; beam, outside of planking, 28 feet 1 inch, and draft, fully loaded, 13 feet—their value for coastwise towing and the heavier class of harbor work is established. The character of these boats is plain and substantial, and in every way equal to the best practice.

Eight Watertight Compartments

The hull is divided into eight watertight compartments by means of seven bulkheads, the two in the forward end and two in the after end being of wood, and the three intermediate ones, as well as the fore and aft coal bunkers, being of steel. The forecastle is immediately aft of the collision bulkhead, is 16 feet in length and extends the full width of the vessel. Next comes a water tank having a capacity of 13,000 gallons. Following this is an athwartship coal bunker, with an 18-foot fore and aft length. Immediately aft of this is the fireroom, after which comes the boiler, with coal bunkers along each side of it and the fireroom. The bunker capacity is 135 tons of coal. The engine room is 26 feet in length, followed by a fresh water tank of 12,000 gallons capacity. A lazarette and store room for ropes and gear is adjacent.

The main deckhouse is 64 feet in length, with four officers' staterooms in the forward end. Two mess rooms for officers and men follow, also a galley and large store room for supplies, arranged in the most approved manner with lockers, bins and shelves. Aft of the galley comes the boiler room and fidley, and still further aft the main engine room, 14 feet in length, with a mean width of 14 feet. Aft of this are toilet rooms, space for steering engine and lockers for engineers' supplies. The captain's stateroom and pilot house are on the upper deck. These are quite roomy and are comfortably furnished and fitted in a plain and thoroughly substantial manner.

The engine is of the compound type, with cylinders 18 and 38 inches in diameter and with piston stroke of 30 inches to develop about 750 horsepower. No pumps are worked from the main engines. The units, consisting of a centrifugal circulating pump, a vertical air pump, a bilge pump, a feed pump, a wrecking pump, a pump for fire service, and a sanitary pump, are separate and distinct. The usual bilge ejector and boiler feed injectors are fitted; in fact, the mechanical installation is thoroughly complete and up to date.

Steam at 185 pounds pressure will be supplied by one Scotch boiler 16 feet in diameter and 12 feet in length. This boiler is fitted with three Morrison furnaces, with separate combustion chambers. These vessels are lighted by electricity throughout and are equipped with searchlight and electric running lights. They will be finished and ready for service about the beginning of 1919. Specifications follow:

Specifications

Length overall	129 feet
Length between perpendiculars	116 feet 8 inches
Beam, extreme	28 feet 1 inch
Draft, loaded	13 feet
Displacement at 13 feet	512 tons
Area, midship section	233 square feet
Prismatic coefficient	.656
Bunker capacity	135 tons
Fresh water capacity	25,000 gallons

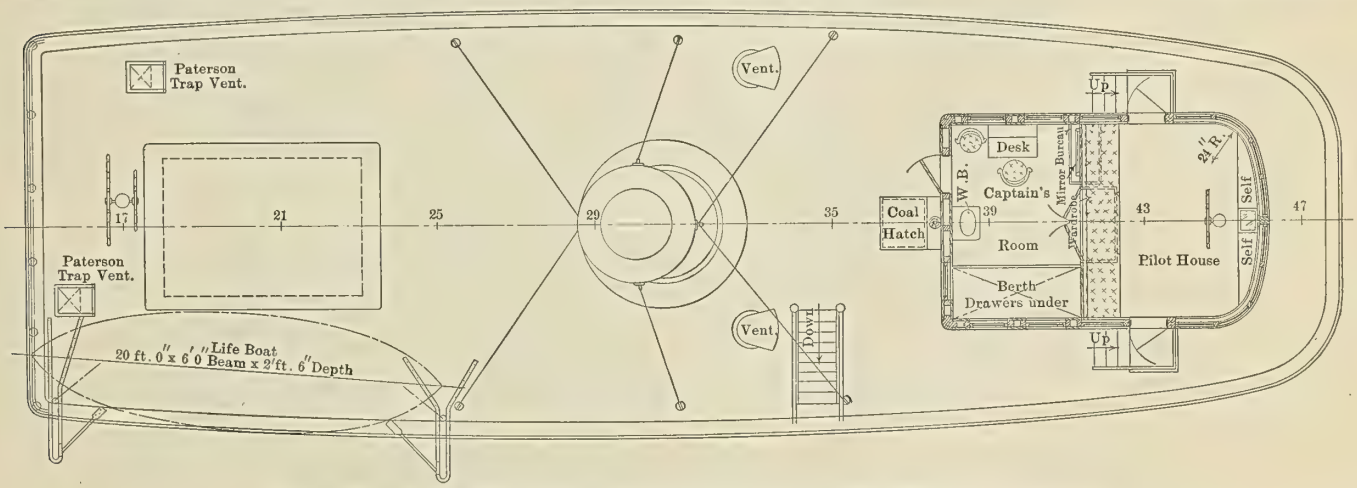


Fig. 1.—Plan of Wood Tug Designed by Gielow & Orr for Todd Shipyards Corporation

Engines

Type	Compound
Cylinder, diameter	18 inches and 38 inches
Stroke	26 inches
Valves, high-pressure piston, double-port slide	Low pressure
Revolutions per minute	140
Indicated horsepower	750
Speed	12 knots
Condensing surface	1,500 square feet
Diameter of piston rods	3⅝ inches
Diameter crank pins	8 inches
Length crank pins	8½ inches
Length connecting rods	65 inches

Propeller

Number of blades	4
Diameter	8 feet 9 inches
Pitch	10 feet 6 inches
Pitch ratio	1.20
Helicoidal area	30 square feet
Circulating pump, centrifugal	8 inches
Capstan, steam	6 inches by 7 inches
Steam steering gear, double engine	4½ inches by 4½ inches
Generating set	5 kilowatts

Boiler

Type	1 single-end Scotch
Pressure	185 pounds
Diameter	16 feet
Length	11 feet 8 inches
Tubes, 348	3 inches
Furnaces, number of	3
Diameter inside	51 inches
Grate area	79.7 square feet
Heating surface	2,613 square feet

Classification Society Necessary to the Merchant Marine

BY "OLD SCOTCH"

The average reader, and, in fact, even the average man connected with the operation or building up of the merchant marine, has but a vague idea as to the functions and great necessity of marine classification societies. In the hope of bringing some light to bear on this subject, therefore, the following elementary description is written.

It is a generally recognized principle that for the conduct of any large business, where the risks to be encountered are too great to be assumed by individuals or corporations engaged therein, it is advisable to divide the losses among all participants in the particular activity, through the medium of insurance societies or organizations, either mutual or general.

Value of Employers' Liability Insurance

Thus we find life insurance societies organized to assume the risk on premature deaths of individuals, thereby providing the means for looking after the dependents of the insured. Again, there are accident insurances to provide for temporary disabilities of bread winners. Fire insurance, probably one of the oldest of the many branches of this activity, protects the individual or corporation from losses due to the ravages of that element. Employers' liability insurances, plate glass insurance, automobile insurance and innumerable other organizations have sprung into being, all based on the proposition of distributing the accidental losses of the individual among many, and thus enabling mankind to develop various branches of industry, where, unaided, the individual would hesitate, or refuse, to assume the risk of development.

The vicissitudes of the sea, among all others, are probably the most diversified. Storm and tempest, reefs and shoals, collisions, fires and other disasters make the successful operation of ships very dependable upon insurance methods.

The investment of money for any purposes is guided by conservatism of the highest type. No one will willingly place his money in any investment unless he can readily foresee, in his own opinion at least, safe returns for its use.

Investors who risk their money in insurance companies depend largely upon the immutable law of averages. The house, or ship, or individual, or thing upon which a risk is taken, must comply with certain rules or regulations, to guard against an undue violation of the laws on which averages are based. In the case of houses or other structures upon land, it must be known how they are built, and whether under certain municipal rules or regulations; for life insurance each must undergo a rigid physical examination to ascertain his condition at the time the risk is taken. All such liabilities are easy to ascertain.

In the case of ships which wander all over the maritime world in quest of business, the ascertaining of pertinent facts upon which to assume an insurance risk is not so easy of accomplishment. "How were they constructed?" and "What is their present condition?" are questions which naturally are uppermost in the minds of those who are asked to risk their money upon the safe arrival of particular vessels.

Regulation and Control a National Matter

The regulation and control of shipping in all countries is a national rather than a local matter, from the very nature of the business in which they are engaged. Governments, as a rule, only take upon themselves part of the responsibility of dictating as to how ships are to be constructed or operated. By certain regulations the state sees to it that precautions are taken to safeguard the lives of its citizens, but the safety of transportation of goods is entrusted almost entirely to private or semi-official organizations, and it is to these that insurance companies must look for information upon which they may assume the risks in which they invest their moneys.

Thus in each great maritime country there has come into being certain so-called "classification societies," whose business it is to superintend the construction and prescribe the rules under which ships are built. They must also, by means of periodical surveys, keep advised as to the condition in which the ships are maintained. An organization of this kind must primarily be one to inspire confidence in the insurance companies and shippers. Nor should it be a money-making institution, though, of course, it should be self-supporting. Its members and agents should be men professionally qualified to pass intelligently upon all technical and practical matters relating to ship building and ship operation. They must also be men of unquestioned integrity and patriotism, fair-minded and diligent. Furthermore, they should have no business connections or affiliations, such as with any concern connected with shipbuilding or operation, in order that their opinions and findings may be unbiased.

American Bureau of Shipping

England, the greatest of all maritime countries, has her British Lloyds, France her Bureau Veritas, and Italy her Registro Navale Italiano.

Quite logically, marine insurance companies prefer to have the classification placed on a vessel, upon which they are to assume a risk, by a society organized and operated by their own nationality. The United States, now about to begin a shipping programme which will place it in the very forefront of maritime powers, fortunately has its own classification society—The American Bureau of Shipping. Started at a time when American shipping activities were at a very low ebb, it has nevertheless maintained its organizations, and at present is well able to undertake the oversight of the immense increase of American shipping in being, under construction, and in contemplation. Insurance facilities form a vital factor in the development and operation of a successful merchant marine. American capital must be enlisted in increasing amounts to satisfy the demands of the trade which is bound to accrue in return for our shipping efforts.

The act creating the Shipping Board, which made pos-

(*Concluded on page* 690)

Analysis of Gas and Gasoline High-Speed Engine Design—II*

Groups of Mechanical Losses Dependent Upon Form of Pipe Work—Volumetric Efficiency and Piston Design

BY HARRY R. RICARDO, B. A.

IN modern high-speed engines every effort is made to obtain the highest possible mechanical and volumetric efficiencies, and these efforts have met with such success that the author can point to examples of quite small engines running at piston speeds as high as 1,800 feet per minute, in which the mechanical efficiency is over 90 percent and the volumetric efficiency over 96 percent, a result which the low-speed school has seldom, if ever, been able to achieve even with the conventional piston speed of only 800 feet per minute. One of the chief problems which the high-speed engine school has dealt with in a very thorough fashion is that of eliminating the mechanical losses, and they have certainly reduced this to a fine art.

The mechanical losses of any internal combustion engine may be divided conveniently into three groups: (1) The losses due to bearing friction and the driving of such auxiliaries as the valve gear, oil pumps, ignition, etc.; (2) piston friction; (3) fluid pumping losses.

The last of these is not, strictly speaking, a mechanical loss at all, but it is customary and very convenient to include it under this head. It is usual to specify the mechanical losses in terms of percentage of the indicated horsepower, but in the author's opinion it is preferable from many points of view, and particularly when the speed is a variable quantity, to classify them in terms of mean pressure per square inch of piston area; that is, in terms of torque rather than power, so that they are directly comparable with the effective mean pressure—all the more so since it is now customary to measure the actual torque in terms of mean pressure per square inch of piston area. This is referred to as the brake mean pressure, i. e., the mean pressure corresponding to the brake horsepower of the engine.

Bearings	0.75 pounds to 1.00 pounds
Valve gear	0.75 pounds to 0.80 pounds
Magneto	0.05 pounds to 0.10 pounds
Oil pump	0.15 pounds to 0.25 pounds
Water pump	0.30 pounds to 0.50 pounds
Total	2.00 pounds to 2.65 pounds

Let us consider the losses included under the first heading. These, of course, are dependent to some extent upon the number of auxiliaries driven from the crankshaft, also upon the number of cylinders between which they are shared, and, to a small extent, upon the weight of the flywheel. The torque equivalent of some of these auxiliaries is dependent upon, and of others, is independent of the speed of rotation. Numerous experiments have been made in order to ascertain the extent of the losses included under this heading, and as a result they have been found to range from 1.5 pounds per square inch mean pressure in the case of a modern 6- or 12-cylinder aero engine up to over 3 pounds per square inch in the case of a heavy single-cylinder gas engine. As a general rule, they may be taken as ranging from 2 to 2.6 pounds per square inch for an average high-speed engine, and may, for a 100-horsepower, six-cylinder engine, be sub-divided. See table above.

* Extract of paper read before the Northeast Coast Institution of Engineers and Shipbuilders.

Piston friction is generally the largest item and is somewhat difficult to account for. In high-speed engines with enclosed crank chambers and forced lubrication the piston may be regarded as being practically oil-borne. Compared with the main bearings, however, the average loading in very much lighter and the rubbing velocity not so very much higher. At first sight, therefore, it would appear that the friction of the piston on the cylinder walls should not be greater than that of an equivalent area of bearing surface in other parts of the engine. That it is, in fact, enormously greater is probably to be accounted for in part by the fact that the motion of the piston is reciprocating and not continuous, and in part by the fact that the lubricating oil is always more or less contaminated and carbonized partly by the escape of a very small quantity of burning gases past the piston rings, and partly by the exposure of the cylinder walls to the high temperature of combustion which tends to carbonize the film of the oil adhering to them. As a result of this contamination the viscosity of the oil is increased enormously, and therefore also its resistance to shear. A very large number of experiments have been carried out by the author and others in order to determine both the cause and extent of piston friction in gas and petrol engines. Briefly, it seems that the main causes are those stated above, and that the extent is almost directly proportional to the average thrust on the cylinder walls and indirectly proportional to the rubbing velocity and the area of surface. It is found that when the area of surface is equal to π times the diameter—that is, when the length and diameter are equal—the piston friction in terms of pounds per square inch can be found from the formula—

$$\frac{\frac{\text{Mean fluid pressure}}{4} + \frac{\text{2 mean inertia pressure}}{3}}{10}$$

Plus a constant which includes the average pressure on the cylinder walls due to the compression and which depends also, to some extent, upon the number and strength of piston rings. This constant may vary from 1.5 to 4 pounds per square inch, but generally averages about 2 pounds per square inch.

This formula is, of course, purely empirical. It is open to criticism on the grounds that the rubbing velocity is not taken into account, and that, therefore, the resistance of the oil film to shear is assumed to be constant. This, of course, is not the case, but the apparent error is largely corrected by taking very prominently into account the average component of thrust due to inertia pressure, which, of course, varies as the square of the speed.

Fluid Pumping Losses

The extent of these losses depends very largely upon the form of pipework and upon the velocity through the piping and valves. Provided that the pipework, and particularly the intake pipe, is reasonably short, i. e., not more than eight diameters, and that the internal diameter is not less than that of the valve port, also that the valve timing is more or less normal, the loss due to fluid pumping may be taken as dependent upon the velocity through the valve ports. This is approximately true in a diagram in which the horizontal scale denotes the average gas velocity

through the valve ports based on the assumption that the valve is fully open throughout the stroke, and where the vertical scale is the mean pressure of the suction exhaust loop. This curve has been prepared from a very large number of indicator diagrams and from motoring tests, and may be taken as being substantially correct and applicable to any class of four-cycle engine.

It is interesting to compare the mechanical losses of three actual engines, each of about 80 horsepower per cylinder:

1. A Diesel engine bore 16.0 inches, stroke 19.0 inches, normal speed 250 revolutions per minute; piston speed 790 feet per minute; weight of reciprocating mass 994 pounds; mean gas velocity through valves 150 feet per second.

2. A gas engine bore 15.0 inches, stroke 24.0 inches, normal speed 200 revolutions per minute; piston speed 800 feet per minute; weight of reciprocating mass 655 pounds; mean gas velocity through valves 130 feet per second.

3. A petrol engine bore 7.25 inches, stroke 0.5 inches, normal speed 1,400 revolutions per minute; piston speed 1,980 feet per minute; gas velocity through valves 130 feet per second; weight of reciprocating mass 11.35 pounds.

	Friction Losses in Terms of Pounds per Square Inch of Piston Area		
	Diesel Engine Pounds per Square Inch	Gas Engine Pounds per Square Inch	Gasoline Engine Pounds per Square Inch
Bearing, etc.....	3.5	3.0	1.8
Piston friction.....	11.8	7.8	7.2
Fluid pumping loss...	4.5	3.4	3.4
Total.....	19.8	14.2	12.4
Brake mean pressure.	75	75.0	118.0
Mechanical efficiency, Percent.....	79	84	90.6

In these figures, in order to make them truly comparative, no account is taken of the air compressor usually fitted to Diesel engines. The indicated mean pressure is taken as 89.0 pounds per square inch in the gas engine and 130.0 pounds per square inch in the gasoline engine.

It may be argued that, while the mean pressure taken in the case of gasoline engines is very nearly the maximum obtainable, that taken in the case of both the gas and Diesel engine is well below the maximum, and that, therefore, the comparison is not a just one. The answer to this is that in both the gas and Diesel engines the cylinder bore is so large that it is not possible to work with higher mean pressures, owing to the excessive heat gradient across the piston and through the walls of the combustion chamber. In the gasoline engine, however, with its small cylinder and thin walls, it is possible to dispose of the heat, and that with the same, or even a smaller, temperature difference between the inside and outside of the cylinder walls and combustion head. Again, in the gasoline engine the mean pressure can only be cut down by throttling the charge as already explained, and not by reducing the mixture strength.

Volumetric Efficiency

It is, of course, obvious that to obtain the best results from any type of internal combustion engine every effort must be made to obtain the highest possible volumetric efficiency, but at the same time it is also of vital importance that the working fluid shall be in a state of the utmost possible turbulence in order to spread and distribute the ignition. This applies with equal, if not with greater, force to Diesel engines, in which the necessary intimate contact of the particles of fuel and air is brought about quite as much by the turbulence of the air within the cylinder as by the spraying of the fuel. In the author's experience, provided that the air in the combustion chamber can be maintained in a state of violent commotion, excellent combustion can be obtained even with very indifferent spraying. The necessary turbulence can be obtained in most cases only by admitting the gas at a high velocity through the inlet valve. The problem, therefore, resolves itself into one of obtaining the highest possible velocity through the valve with the least possible wire drawing, i. e., the nozzle coefficient of the valve opening regarded as an orifice must be as high as possible. Provided that the valve and its passages are designed to give the highest orifice coefficient, the author has found that the best all-round results are obtained when the velocity through the inlet valve is in the neighborhood of 130 feet per second. With carefully designed valve passages and no further restriction or change of direction after the gases have passed the valve, it is possible with this velocity to obtain a volumetric efficiency within 3 percent of the maximum possible figure, while the degree of turbulence is sufficient to give within two or three percent of the highest possible efficiency, i. e., any lower velocity through the valves results in an appreciable drop in the efficiency and power output due to insufficient turbulence, while any higher velocity results in loss of volumetric efficiency, due to wire drawing.

It can be proved that if the swept volume of the cylinder is completely filled with working fluid at atmospheric pressure, the volumetric efficiency in terms of standard pressure and temperature will be approximately 82.7 percent of the swept volume.

Piston Design

Of the individual mechanical features of high-speed engines, by far the most important is the design of the piston, for not only does piston friction constitute the bulk of all the mechanical losses, but the weight of the piston itself is responsible for a very large part of the load on the bearings and for the stresses in the engine structure, due to opposing couples. The design of the piston must be carried out with a view to—

1. Dissipating Heat.—This is met by the use of copper aluminum alloys, whose conductivity is about four times that of cast iron.

2. Reducing Weight.—This, of course, is a question of suitable distribution of the material, so that the loads are transmitted as directly as possible from the crown of the piston to the connecting rod and from the connecting rod to the cylinder wall.

3. Reducing as far as possible the area of surface in contact with the cylinder walls, i. e., cutting down bearing surface where it is not required.

4. Preventing distortion.

Conventional Design of Trunk Piston Defective

The conventional design of trunk piston as used in most single-acting, slow-speed, internal combustion engines is probably about as unimaginative and as defective as it could be. In the first place, the dissipation of heat is catered for by the simple but unenterprising method of piling on masses of metal instead of by attempting to employ a material with a higher conductivity. In the second place, the whole of the pressure from the crown is transmitted through the side walls of the piston and thence to the two extreme ends of the gudgeon pin, with the result that these walls have to be abnormally thick; heavy gudgeon pin bosses must be employed, which results in distortion, and finally the deflection of the gudgeon pin sets up a further distortion of the piston and gives rise to trouble with the gudgeon pin bearing. It is usual also in slow-speed engine practice to make the whole length and circumference of the piston below the piston rings bear

against the cylinder walls, though much of this area is useless as bearing surface and merely serves to increase piston friction. In high-speed engine design, however, every effort is made to reduce the weight and friction, on the one hand by cutting down the weight and bearing surface of the conventional design to the furthest possible limit, and, more recently, by departing from the more conventional form.

Gudgeon Pins and Bearings

In nearly all large internal combustion engines the gudgeon pin and its bearing are a source of more or less anxiety. In small high-speed engines, however, this pin and its bearings seldom, if ever, give the slightest trouble. The main reasons for trouble in large engines appear to be: (1) Distortion of the piston; (2) bending of the gudgeon pin; (3) severe average loading due to the heavy inertia forces.

Of these by far the most important is the bending of the gudgeon pin, due to the fact that the load from the piston crown is delivered to it at its extreme ends and is taken more or less from the center. The author has found that by using a very short gudgeon pin and delivering the load to it at points as close to the center as the connecting rod small end bearing will allow, it is possible to employ a very much smaller bearing surface than usual, and that with considerably less wear than with the convential long gudgeon pin and very wide connecting rod bearings. Further, the wear that takes place on the gudgeon pin owing to the small arc through which the connecting rod rocks is very local and therefore cannot be effectively corrected by rebushing the connecting rod or taking up the bearing.

Wear of Slow and High-Speed Engines

In both high and slow-speed engines the general wear and tear may be measured in terms of the bearing wear, for it may be assumed that the life of the other working parts is at least proportional to that of the bearings. Assuming that the system and supply of lubrication is the same in both cases, the wear may be taken as being proportional to the product of the mean average loading on the bearings and some function of the rubbing velocity, probably about the square root. It is interesting, therefore, to compare the average load on, say, the connecting rod big end bearing of a Diesel engine, a gas engine and a high-speed gasoline engine, all of about 80 horsepower per cylinder, the Diesel engine running at 250 revolutions per minute, the gas engine at 200 revolutions per minute and the gasoline engine at 1,400 revolutions per minute. The projected area of the crank pins in the three examples are: Diesel engine, 94.3 square inches; gas engine, 45.1 square inches; gasoline engine, 11.4 square inches.

The average loading on the crank-pin bearing is made up of (1) the actual fluid pressure in the cylinder, (2) the inertia pressure due to the reciprocating masses, (3) the centrifugal loading due to the weight of the rotating portion of the connecting rod.

These are not all cumulative, but when the necessary corrections have been made the average loading will be the same when the Diesel engine is running at 360 revolutions per minute, the gas engine at 250 revolutions per minute, and the gasoline engine at 1,370 revolutions per minute.

It might be argued that the life and durability of any engine depends upon other parts than the bearings, such, for example, as the exhaust valves and the valve gear generally. In modern high-speed engines, however, provided that the valve gear is properly designed and that multiple valves are used when either the stresses in the gear or the heat flows become excessive, and provided also that the exhaust valves are seated directly onto water-cooled seatings and not, as is sometimes the case, in detachable housing, then trouble with valves is of rare occurrence. Exhaust valves nowadays generally require grinding after about the same number of hours' running in either high-speed or low-speed engines, and breakages have become things of the past.

The question of balancing and the elimination of vibration is, of course, a vital one, particularly in small high-speed engines, most of which are generally fitted to light structures, such as motor cars and aeroplanes. In such cases it is customary to employ four or more cylinders. With four cylinders and cranks at 180 degrees, all the primary forces are balanced and the couples formed by each pair of pistons are opposed to one another so that they exert a bending moment on the structure of the engine but cause no external disturbance. In very high-speed engines it is found that the unbalanced secondary forces due to the angularity of the connecting rods cause a serious disturbance.

Torsional Vibration of Crankshaft

There is yet another and frequently very troublesome source of vibration in six-cylinder engines, namely, torsional vibration of the crankshaft. This is due to the fact that the end of the shaft furthest from the flywheel is, so to speak, wound up when the maximum turning moment is applied to it and released when the pressure is released. At certain speeds this alternate winding up and release coincides with the natural period of the crankshaft, with the result that the shaft vibrates excessively and the reciprocating masses which are attached to it vibrate with it and impart their vibration to the whole structure. Such torsional vibration can be prevented almost entirely by the use of the "Lanchester" damper, which consists of a small flywheel mounted loosely on the crankshaft and connected to it through the medium of a friction clutch. The flywheel rotates at a constant angular velocity, and any relative movement of the end of the crankshaft results in the slipping of the clutch. The damper does not prevent the crankshaft from being wound up and released, but it does effectively prevent it from continuing in a state of vibration. This damper has proved most effective on high-speed engines, and one has recently, at the author's advice, been fitted to a large slow-speed, six-cylinder Diesel engine, which torsional vibration of the crankshaft had proved so troublesome that the engine could not be used. Since fitting the damper this trouble has entirely disappeared, and the engine is now running quite satisfactorily.

Beresford Advocates Younger Admirals

In middle life, when the energy of youth is waning, when the illusions of youth are dissolving, and when the hopes of youth are fading, Admiral Lord Charles Beresford has said, a man tends to relax, both physically and mentally. His choice is determined, and the incentive of ambition has wasted away. Because he no longer makes the effort required to keep him in condition, his muscles become soft, his chest narrow, his shoulders stoop, his latitude increases out of all proportion to his longitude. At the same time, his mental processes become stereotyped; he becomes insusceptible to new ideas, and he begins to lose initiative. It is for this reason that Admiral Beresford has always advocated the making of admirals at a much younger age than the age at which captains are promoted under the present system.

Fig. 1.—Largest Shipyard in the World—Fifty-Two Shipways in Service

Hog Island, the Greatest Shipyard in the World*

Review of the Conditions That Preceded Planning of Yard—Adopting Type and Design of Boat—Troubles Encountered and Overcome—History of the Island

BY W. H. BLOOD, JR.

TO fully comprehend the development, plan and scope of the Hog Island shipyard, one must know the conditions which called for it and the steps which led up to its creation.

On May 7, 1915, the *Lusitania* was torpedoed, and shortly after, during the same year, other British steamers, the *Arabic, Ancona* and the *Persia*, to say nothing of numerous smaller vessels belonging to the allied nations, went sent to the bottom. Many neutral steamers, regardless of nationality or destination, were also sunk, until the total tonnage destroyed in 1915, according to British Admiralty reports, ran up to 1,700,000 gross tons. The record of sinkings for 1916 was nearly 2,800,000 gross tons, and it looked at that time as if Germany might continue to keep up or possibly increase this ratio. It was evident that the world's supply of ships was fast diminishing and there arose an urgent demand that the United States start at once the building of a merchant marine, a thing long talked of but never realized.

Congress, recognizing that such a condition existed, on September 7, 1916, passed an act "To establish a United States Shipping Board for the purpose of encouraging, developing and creating a naval auxiliary and naval reserve and a merchant marine to meet the requirements of the commerce of the United States with its territories and possessions and with foreign countries; to regulate carriers by water engaged in the foreign and interstate commerce of the United States, and for other purposes."

Under the Emergency Shipping Fund Provision of the Urgent Deficiencies Appropriation Act, approved June 30, 1917, the President was, among other things, empowered "to place an order with any person for such ships or material as the necessities of the Government, * * * may require during the period of the war, and which are of the nature, kind and quantity usually produced or capable of being produced by such person." The President was also authorized to exercise the power granted to him and to expend the money appropriated through such agencies as he might determine. This power was delegated to the United States Shipping Board Emergency Fleet Corporation by executive order, and thus a national organization for building merchant ships was established and the expenditure of $500,000,000 for this purpose was authorized.

On April 6, 1917, the Declaration of War against the Imperial German Government was signed by President Wilson.

In May, 1917, General Goethals, who was then general manager of the Emergency Fleet Corporation, discussed with the officers of the American International Corporation of New York the programme then laid down by him of utilizing to their maximum all of the existing ship-

* Read at the twenty-sixth general meeting of the Society of Naval Architects and Marine Engineers, held in Philadelphia, November 14 and 15, 1918.

building yards, and, in addition to this, the construction of new shipyards in which several million tons of ships could be manufactured faster than they had ever been produced.

For several years prior to the war the total output of all the yards of the United States only once exceeded 400,000 deadweight tons per annum, but it was believed that these yards could be crowded up to produce 2,000,000 tons. Still, this was not nearly enough, as it was figured that we needed at least 5,000,000 tons simply to maintain an army of 1,000,000 men in France, to say nothing of getting them over or of increasing the size of this expeditionary force. In other words, it seemed that we must have, simply to supply our own immediate needs, some 3,000,000 tons at the very least, over and above the amount which the established shipyards could produce in a year, and the question was how this tonnage should be secured.

Old Methods of Construction Inadequate

It was admitted that the old methods of construction were inadequate to supply the unprecedented demand, and it seemed that the only way to make good the deficiency was to build a standardized fabricated ship which could be made in quantity. This method of construction contemplated the utilization of going shops all over the country in which the various parts and pieces of apparatus could be made and the shipyard itself could give its entire attention to the assembling of these parts or units.

It was not until June 30, 1917, on which date the Urgent Deficiencies Act was approved, that the Emergency Fleet Corporation was in a position to act upon the tentative plan submitted by the American International Corporation, and, due to changes in the personnel of the Emergency Fleet Corporation and for various other reasons, the execution of this contract was deferred until September 13, 1917. Thus you will see what we have done in a year.

The plan, as it had been outlined by the officials of the American International Corporation, was the construction of a mammoth ship assembling yard and the building of numerous ships, all of the same design. In other words, the scheme was to build a very large manufacturing plant and then to undertake the quantity or "mass production," as our English friends call it, of one type of standardized, fabricated ships.

This meant the design of a simple ship, one in which the plates, sections and angles could be punched and fashioned in the structural steel and bridge shops, for these were the only steel working plants available. The "fabricated ship" was not a new idea, nor was it developed over night, but, as a matter of fact, the germ lay in embryo form for years and only the national crisis caused it to be hatched full fledged to meet the sudden exigency.

Ridicule from the Old-Timers

Many of the old shipbuilders ridiculed the plan of the American International Corporation, saying that the scheme was impracticable, that the shipyard was too large and that the plates punched and bent in so many different shops would not fit. None of those "old-timers" had ever been able to get an order to build a large number of ships all of one design, and the scheme had never been fully tried out, and was therefore something of an experiment.

The officers of the American International Corporation, however, due to their experience in the operation of the New York Shipbuilding Corporation at Camden, N. J., where the parts of the ships were "fabricated" in their own yard, believed that it could be done and offered to construct a new shipyard in which fifty ships could be

Fig. 2.—Hog Island Shore Line Before the Coming of the Shipyard

built at one time, and where a proportionate number could be outfitted at the same time. To build a shipyard with fifty ways was an audacious undertaking, for it was nearly ten times as big as the ordinary shipyard in this country and nearly one-quarter as large as all of the shipyards in Great Britain combined, the reputed capacity of that historic shipbuilding country being only 209 ways.

It was believed that the American International Corporation was better able to undertake this colossal job than any other organization in the country, for the men at the head of it were courageous, were familiar with big affairs, and were willing to stake their established reputations that it could be done. In the first place, the American International Corporation could of itself control sufficient capital to put through almost any enterprise, regardless of its size. It had a capitalization of $50,000,000, and besides this a strong financial backing. Secondly, it could secure the services of the engineering and construction organization of Stone & Webster, inasmuch as Mr. Charles A. Stone, president of the American International Corporation, was the senior partner of the firm of Stone & Webster. This organization had been for many years a leader in executing large engineering and construction undertakings. Thirdly, it could also supply the shipbuilding talent of the New York Shipbuilding Corporation, for the controlling interest in this company had been bought by the American International Corporation, and it was well recognized that it had one of the best developed shipbuilding plants in the country.

Had Large Automobile Plants in Mind

The American International Corporation offered to build the shipyard at cost. Its offer was accepted, and it has done better than this: it has not only built a plant costing over $50,000,000 for which it has received no fee whatsoever, but it has put up $1,700,000 of its own money to purchase the land and has paid out of its own pocket overhead expenses already in excess of $1,000,000.

The scheme to build a shipyard five or six times as large as the largest in the country and to assemble or manufacture ships as automobiles are manufactured was a bold one. There were no precedents to follow, much pioneering work had to be done, and many engineering guesses had to be made. There was no time to make complete plans in advance, but the work had to be started at once, and the development of the plans had to be made as the construction proceeded. "Speed" was the essence of the contract and has been the guiding motive from start to finish. The importance of getting the yard finished at the earliest moment is perhaps best realized when one considers that the commercial rental value of the 180 ships under contract, at rates fixed by the chartering committee of the United States Shipping Board, is $460,000 per day, or nearly $14,000,000 per month, to say nothing of their value as a factor in determining the duration of the war.

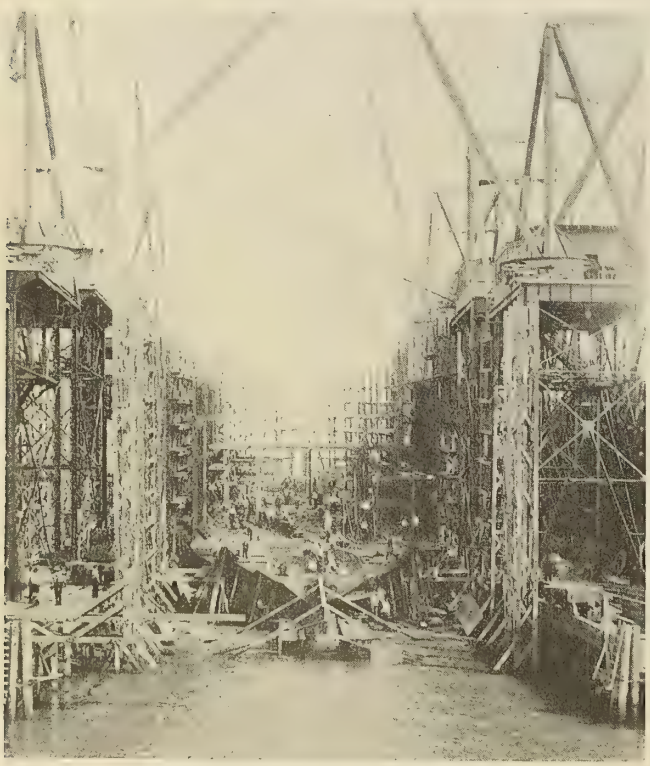


Fig. 3.—Way No. 19, Hull No. 507

Fig. 4.—Winter Operations Preliminary to Building

By a fortunate coincidence, a company affiliated with the American International Corporation had for months been considering the development of a large port terminal, and in their investigations they had studied every available waterfront property of any considerable size between Boston, Mass., and Baltimore, Md.; knew the location of each of these, the prices for which they could be bought, and many of the physical facts surrounding them. All of this valuable data was immediately available when the contract was signed. The locations between Boston and New York were promptly eliminated because it was obvious that any yard built in that territory would be dependent on one single railroad, which was then already overburdened. Locations directly around New York could not well be considered because other shipyards already established in that neighborhood needed all the men they could get. The most desirable location which presented itself, after eliminating the others one by one, was the tract of land near Philadelphia, on the Delaware River, called Hog Island. The arguments in favor of accepting this location were as follows:

First, the tract of land contained 900 acres, nearly level, entirely vacant, and could be acquired by purchase from one individual and at a reasonable price.

Second, it was on deep water, for the Delaware River

Fig. 5.—View Looking East from Way of Group 2, Showing Pile Driving Operations

Fig. 6.—View Looking East from Way No. 1 Showing Forest of Derrick Masts

has a 35-foot channel directly in front of Hog Island, which runs to the sea.

Third, it was inland, away from enemy attack, being practically 100 miles up the river from the Delaware breakwater.

Fourth, it was on fresh water, for, while there is a tide of some 5 or 6 feet, the water is not even brackish.

Fifth, it was near a large industrial city, from which labor could be drawn and in which some housing facilities could be obtained.

Sixth, it was so located that direct connections could be made with three of the large railroad systems—the Pennsylvania Railroad, the Philadelphia & Reading Railroad, and the Baltimore & Ohio Railroad.

Seventh, it was the nearest available point on tidewater to the steel mills and fabricating shops of Pennsylvania and of the Middle West.

Eighth, it was possible to secure from an already established plant the electric energy needed to run the yard.

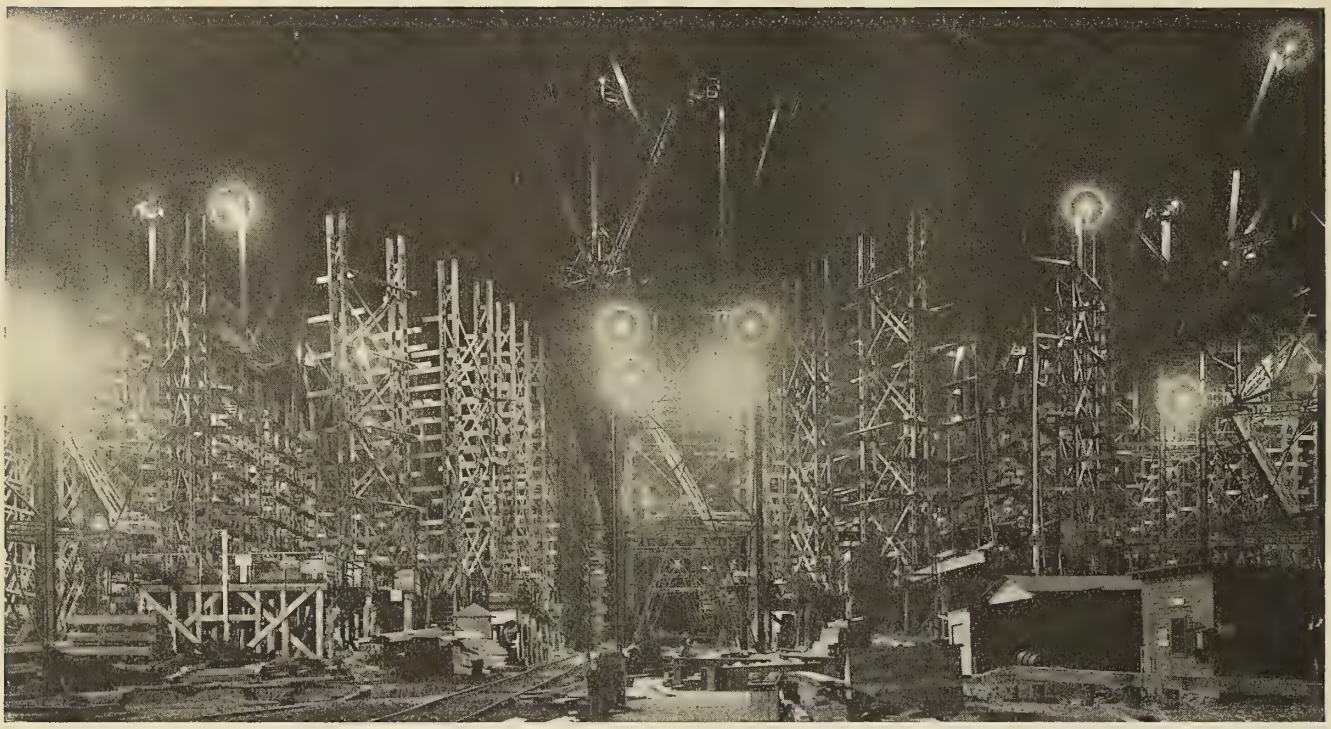


Fig. 7.—Typical Lighting of Shipways at Night That Work May Proceed Uninterrupted

Conditions That Changed Daily

In attempting to write a history of the development of Hog Island, it is an almost impossible task to describe chronologically the steps which took place, especially as conditions changed almost daily and as engineering and construction proceeded hand in hand.

The first sketch of the yard is like the ultimate development in only one particular—they both contemplated building fifty shipways. A good-sized shipyard in pre-war days contained five or six ways, and this seemed to be a workable unit. It was desired to turn out in this new yard a million and a half deadweight tons per year, and it was thought that when the yard was under full swing four ships per way could be built each year. The conclusion, therefore, was reached that fifty ways, operated in ten groups of five ways each, would be workable.

The experience of the New York Shipbuilding Corporation indicated that it required only about half as long to outfit a boat as to get it ready for launching—this ratio, of course, being more or less flexible—so that to have ample room for outfitting, a wet basin with seven piers, each 1,000 feet long and accommodating four ships, or a total of twenty-eight, was planned and a general utility pier between the ways and the outfitting piers was decided to be advisable.

It was expected at the outset that Hog Island would build a vessel of only one type, this being the 7,500-ton, 11½-knot cargo ship, 400 feet long and 54 feet wide, and the original plans and estimates were made on this basis; but the second order for ships given the corporation was for an 8,000-ton, 15-knot combined troop and cargo ship, 450 feet long, 58 feet wide. This change made many alterations in plans necessary, added much to the cost, and prolonged the time of completion of the yard.

Analysis of the Plan of Yard

Looking at the plan of the yard as it is now being constructed, the track layout excites interest, and a study of it shows its simplicity. As ships were to be manufactured in quantity rather than built singly, it was evident that adequate storage space must be provided for piling up plates, sections and other parts, so that they would be ready for immediate use. The plan of storage adopted was that of piling together all plates of the same kind or number, and it was hoped that material for twenty-five boats might always be "in stock," so that the manufacture of ships might go on uninterruptedly, and the storage space was laid out on this basis. Unfortunately, however, this ideal has never been reached, for, while there are sizable piles of some material, the stock of other shapes is still small.

The loaded freight cars come in on a branch of the Pennsylvania Railroad at the northwestern end of the yard from one of the three trunk lines and enter the main classification yard, where they are sorted out. These cars then discharge the steel in one of the two main storage yards—that for the "A" or 7,500-ton boats goes to the "A" yard, and that for the "B" or 8,000-ton boats

Fig. 8.—View of One of the Piers Where Material is Received for Distribution

Fig. 9.—Early Operations of Driving Piles and Filling In for the Foundations

Fig. 10.—View Showing One of the Mammoth Storage Yards and Intricate Track Layout

goes to the "B" yard. Each shipway, it will be noticed, has a track running down its full length, and each outfitting pier has two tracks on it. Tracks are also carried to each of the warehouses and to all the shops. Then there are also two smaller yards, called the "C" and "D" yards, which are primarily for the storage of material other than steel. The total standard gage track within the shipyard aggregates 80 miles, and the company operates 450 of its own cars, as well as 20 locomotives and 70 locomotive cranes.

A casual observer of the plan of the track layout might criticise the "neck of the bottle" which appears between the "A" and "B" yards. The answer to this criticism is that, while provision has been made for additional tracks at this point, the actual operation thus far shows that they are not needed. It will also be noted that each warehouse and each outfitting pier has a roadway in which materials can be handled by truck. The total roadways within the plant aggregate 18 miles and motor-driven vehicles are used exclusively.

It was stated earlier in this paper that the fifty shipways are divided into ten groups of five each. As a matter of fact, each five ways are operated as independent shipyards, and each yard has its own administration building, service building and tool building. Each way is provided with four steel towers or derricks, and each derrick has two wooden booms, so that there are eight "hooks" per ship, a total of 440. This system of handling material was decided upon because of the difficulties of obtaining an adequate number of traveling cranes with the necessary steel for supporting them. The towers took much less steel, and wooden booms were easily and quickly constructed.

Forty of the shipways are on wooden pile foundations, while ten are concrete ways, erected on concrete piles. The use of concrete gave a diversity factor in construction material and made an admirable fire break in the mile and a quarter of ways.

Between each of the yards there is an air compressor plant, serving two yards, but the supply piping is so connected through the entire shipyard that any individual compressor plant may be by-passed in case of accident. The outfitting piers also have two compressor plants. The total capacity of these plants together is 75,000 cubic feet of air per minute, which makes it the second largest compressor installation in the world, the one at the Rand Mines in South Africa alone surpassing it.

Directly back of the ways buildings and also at the head of the outfitting piers are numerous warehouses in which the lighter, fragile and perishable material is stored. These are one-story buildings and they are each divided into four sections by fire-walls, thus minimizing the conflagration hazard. In addition to this, there is nearing completion a large four-story concrete warehouse, the floor area of which is 400 feet by 172 feet.

Directly in the center of the plant is the group of executive buildings, the principal one of these being the administration building, which houses the president and several vice-presidents and their assistants, the accounting organization, purchasing department, and, besides this, the local representatives of the Emergency Fleet Corporation, who are in direct supervision of the Hog Island plant for the Government.

The adjoining building, originally designated as the engineers' building, is now called the ship administration building. This contains the engineers and the large drafting force. Next in order comes a central garage and then the employment building. The employment department at Hog Island is called the Industrial Relations Department, as the organization has to do not only with the employment of the men but also their welfare and housing. Admission to the employment department is made possible

through a special gate, where no passes are required. All other gates at the yard require a special pass or identification tag before anyone can enter.

Directly opposite the administration building is a cafeteria, in which light luncheons are served to the clerks, foremen and any others who may wish to eat there. Across the street from the ship administration building is located one of the best first-aid hospitals in the country. It is manned by an efficient staff of doctors and nurses. It has an operating room, a first-aid room, a modern X-ray outfit, a ward with twenty beds, a dentist's chair, which is in operation 24 hours a day, and four motor-driven ambulances. There is also in this same group of buildings a fireproof telephone plant, which contains a 22-position switchboard and maintains connections with 2,000 stations scattered throughout the island, this plant being equivalent to that used in an ordinary city of 50,000 population. Adjoining the telephone building is the fireproof reinforced concrete records building. In it all the operating records are kept and the Powers card record system of following all shipments from the time they leave the factory to the time they are placed in position on the ship. Besides the above, there is a guards' barracks, which houses 200 of the guards and also contains a room in which a district magistrate holds court each day. Adjoining this is a small jail. A fireproof brick "bank" building, so called, is also found in this group. It is primarily a depository for the payroll funds and was found necessary, as all employees are paid off in cash each week. In this group, as in all of the other groups of buildings, there is a local central heating plant, which furnishes steam to all the buildings by means of insulated overhead pipes.

Perhaps next in importance are the shop buildings. They are located toward the eastern end of the yard, near the "A" storage yard and back of the shipways. As we approach the shops from the west, we first reach the air tool shop, which is devoted entirely to keeping in repair 6,500 air tools—riveters, reamers, drills and grinders—which are used on the job. Next come the galvanizing and pipe shops and then two machine shops. The largest building in the plant is the plate and angle shop, which is 638 feet by 223 feet. This is arranged with three bays, each bay having two traveling cranes. It is equipped with furnaces and bending tables, rolls, punches, shears, etc. Next is the template shop, whih needs no particular explanation, except the statement that, when building fabricated ships, templates have to be made for every piece of steel entering the ship. The plate and angle correction shop, as its name would imply, was erected more or less as an emergency shop to take care of errors and omissions in fabricating and to act as an insurance against fires, strikes or losses in shipment, which might delay deliveries from outside shops.

The shop plant at Hog Island is comparatively small, as more than 95 percent of all the material entering the ships is being fabricated in outside shops. A few plates are being taken care of in the plate and angle shop. There are smith shops in the group, one for solid work and another for miscellaneous smith work.

Besides the buildings already mentioned are two structures called the ship foundation template buildings. In one of these the complete power plant for the "A" boat has been erected, consisting of three Babcock & Wilcox boilers, a 2,500-horsepower General Electric (Curtis)

Fig. 11.—View Looking North Along Main Street, Which Divides Shipways from Shop Buildings

Fig. 12.—Groups of Hog Island Track Spurs and Main Administrative Buildings

Fig. 13.—Close-Up of Ways, Administrative Buildings and Tool Houses

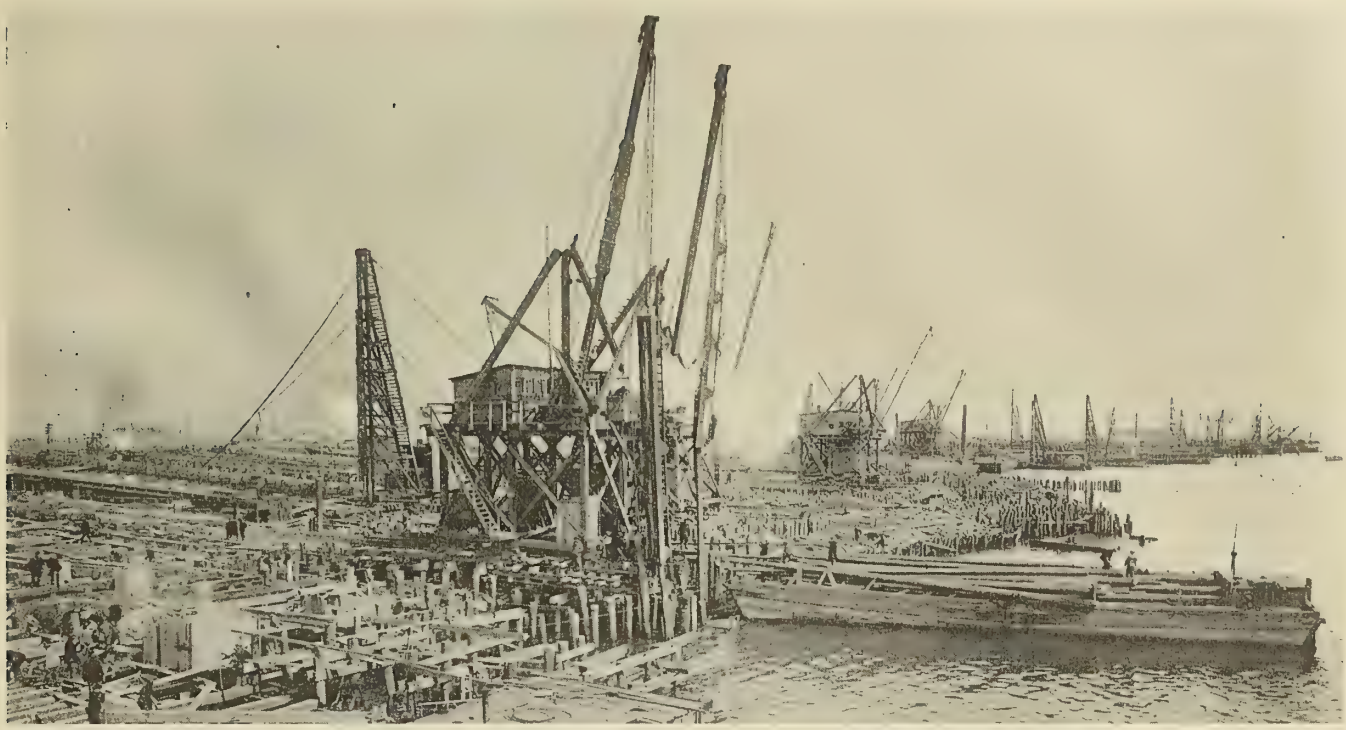


Fig. 14.—View Looking Upstream During Early Days of Intensive Preparation

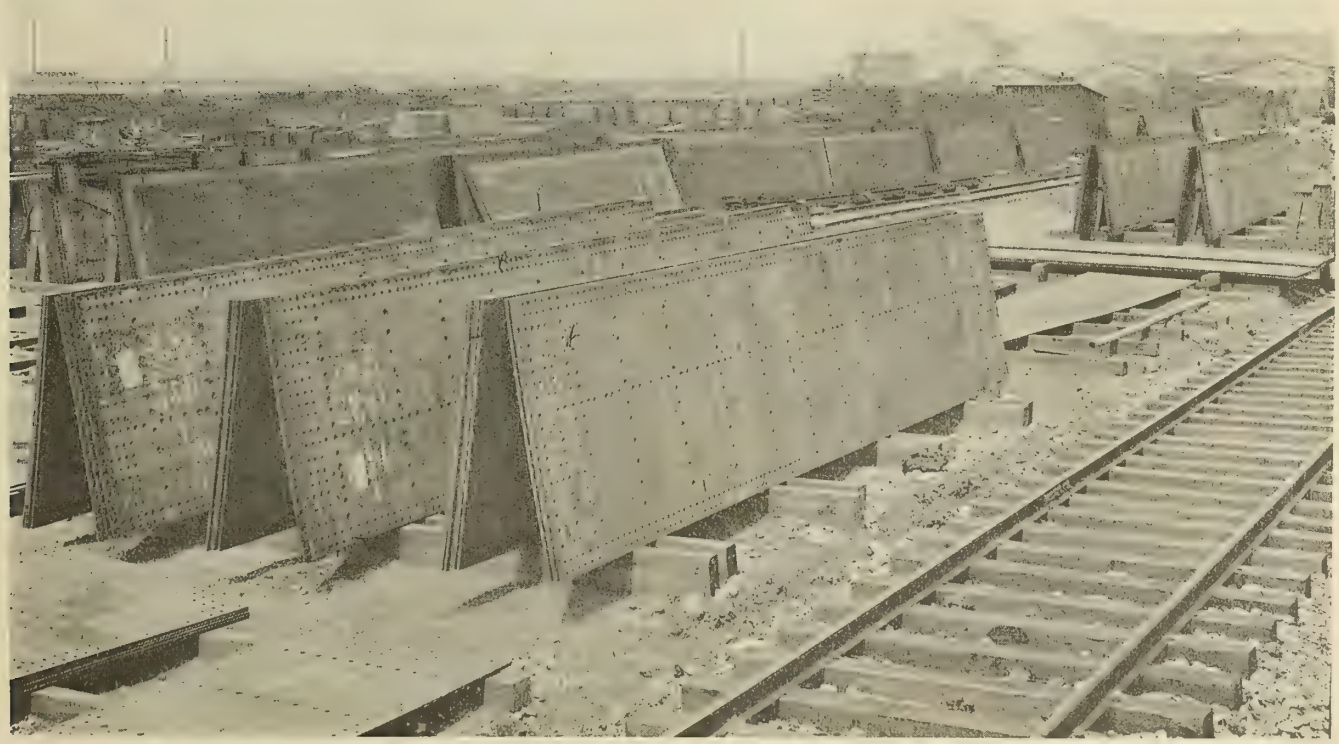


Fig. 15.—Ship Steel Racked in Storage Yard Ready for Immediate Use

geared turbine, with its heater, pumps, condensers and other auxiliaries. This installation was made for the purpose of instructing the installation crews, students and others, and to make sure that all the calculations and measurements of the engineers and draftsmen had been properly made. In like manner, the other ship foundation template building contains a "B" installation, consisting of six Babcock & Wilcox boilers, a 6,000-horsepower General Electric (Curtis) turbine, and the auxiliaries. This entire group of buildings is also heated from a local, central heating plant.

Outside the yard are the living quarters. Here there are barracks for 6,000 men. Each building is a two-story structure and houses 100 men in eight separate wards. These compare most favorably with the army barracks. There is a second guard barracks here which accommodates 200 guards. (A third one is located in the extreme eastern end of the yard.)

Health and Morals of Workmen Considered

The hotel, used principally by the officials, heads of departments, chief assistants and guests, is modern in every respect, and good meals are served here at cost. One of the four fire stations is located here. The department contains 100 men and 16 motor-driven pieces of apparatus. The other three fire stations are located at strategic points within the yard.

There are two large temporary mess halls near the barracks, but these have been practically discontinued, as now the workmen are fed in the service buildings near the ways. During the construction period some 13,000 meals were served daily in these mess halls at 30 cents each. In all, there are at present fourteen eating places on the island, beside the large cafeteria and hotel.

A Young Men's Christian Association building completes the living section of the plant. Its auditorium seats 2,000. It also contains a large gymnasium, twelve billiard tables, locker rooms, shower baths, besides numerous classrooms on the second floor. These buildings are all heated from a local central plant.

Establishing Local Utilities

As Hog Island is outside of the limits of the city of Philadelphia, it was necessary to establish its own local utilities. A domestic water plant, taking water from the Delaware River, together with a filtration and treatment plant, was installed. To distribute this drinking water through the island requires 120,000 feet of piping. A high-pressure piping system for sanitary and fire purposes also covers the island. This requires 90,000 feet of pipe, and raw water is furnished from three motor-driven pumping plants. The ordinary operating pressure is 80 pounds, but on the outbreak of a fire it is run up to 200 pounds. There are 260 fire hydrants systematically located. A complete sewerage system has been put in with two Imhoff tanks and necessary sludge beds. Sewer lines are 73,000 feet in length, and the capacity of the system is ample for a population of 35,000. Electric power is used throughout the yard. The current, purchased from the local company, comes in over a steel tower transmission line at 66,000 volts and goes to a sub-station near the center of the yard. The capacity of this sub-station is 30,000 kilowatt volt amperes, of which 6,000 is reserve, and the connected load is something over 40,000 horsepower. The various electric systems require about 3,000,000 feet of cable, all of which has been placed underground. There are 900 motors in the yard, ranging from 1/30 horsepower to 1,000 horsepower in size. The yard, especially around the ships, is well lighted with flood lights and otherwise. Eighty thousand lamps of all kinds are in use here.

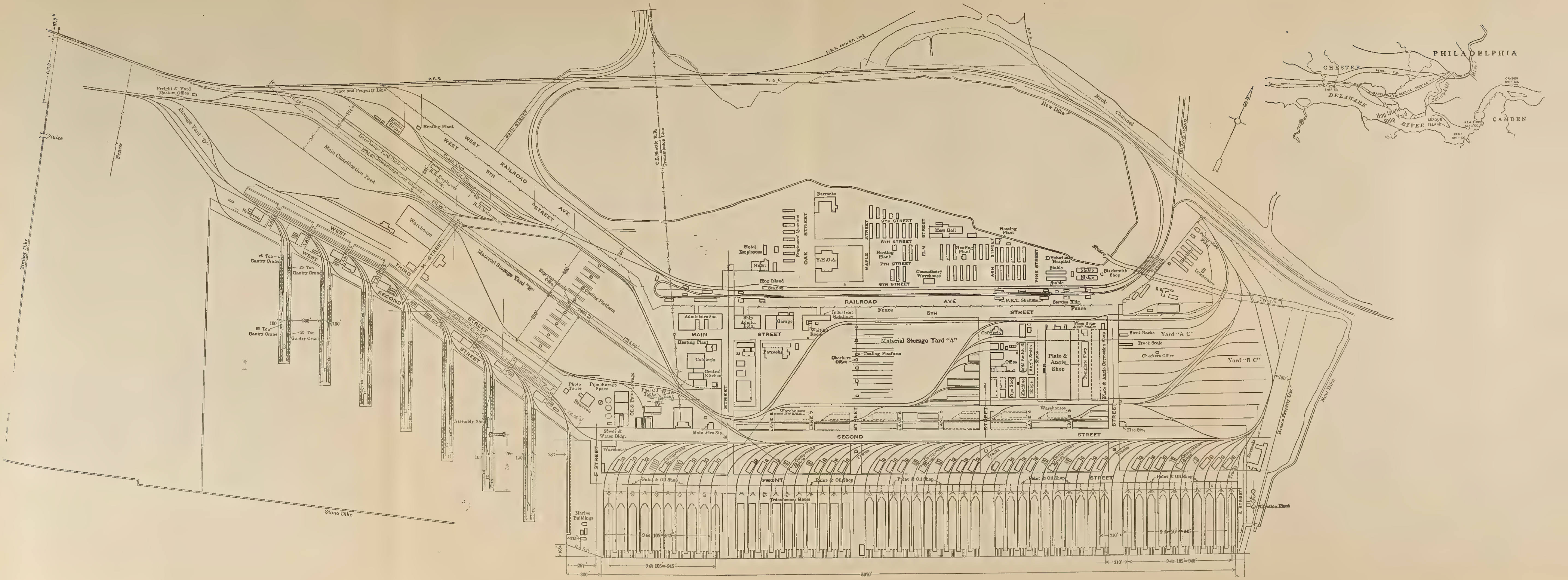
Fig. 16.—Thawing Ground With Live Steam Before Excavating

There are two fuel oil tanks, each holding 100,000 gallons, from which pipes are run to the principal shops where the fuel is used in the furnaces. The present consumption is about 1,200 gallons per day.

To get to Hog Island during the construction period was difficult, as there was no regular transportation to the yard. The nearest lines were a mile away, while others were a mile and a half off. At the present time these difficulties have been removed, as a physical connection has been made with the steam lines and a large loop established within the yard, having three stations, each about half a mile apart. Service is furnished by ten trains, carrying from ten to fourteen cars each. An extension of the Philadelphia Rapid Transit Company now furnishes excellent trolley service direct to the island, and connection is thus furnished with all the lines of this company throughout Philadelphia. The Philadelphia & Southwestern Company, an independent line, also cares for a few thousand men who live in the southern section of Philadelphia. Two large steamboats also run from the wharf at way number 10 direct to the foot of Chestnut

Fig. 17,—Yard Employees Before Main Administration Building

GENERAL PLAN AND TOPOGRAPHY OF HOG ISLAND SHIPYARD


P. R. R.
P. & R.
P. R. R. 60TH ST. LINE
Fence and Property Line
Freight & Yard Masters Office
Sluice
Fence
Timber Dike
Storage Yard "D"
Main Classification Yard
Interchange Yard Outbound
1230.67 Interchange Yard Inbound
Engine House
Heating Plant
Coach Yard
Cinder Pit
R.R. Employees Bldg.
R.R. Maintenance
WEST RAILROAD AVE.
WEST 5TH STREET
84TH STREET
C.L. Shuttle R.R.
Transmission Line
New Dike
Back Channel
ISLAND ROAD
Reservoir
Warehouse
WEST THIRD STREET
WEST SECOND STREET
H STREET
25 Ton Gantry Crane
Material Storage Yard "B"
Superintendents Office
Coaling Platform
Machinists Shop
Electrical Shop
Assembly Shop
Stone Dike
Barracks
Engineers' Quarters
Hotel Employees
Hotel
OAK STREET
Y.M.C.A.
MAPLE STREET
9TH STREET
8TH STREET
7TH STREET
6TH STREET
ELM STREET
ASH STREET
PINE STREET
Mess Hall
Heating Plant
Commissary Warehouse
Veterinary Hospital
Stable
Blacksmith Shop
Fumigation Plant
Stables
Incinerator
Trestle
Hog Island Station
RAILROAD AVE
P.R.T. Shelters
Service Bldg.
Fence
5TH STREET
Administration
MAIN STREET
Ship Admin. Bldg.
Garage
Industrial Relations
Waiting Room
Heating Plant
Cafeteria
Central Kitchen
Barracks
Material Storage Yard "A"
Coaling Platform
Checkers Office
Office
Bolt Smith & Angle Smith Shops
Pipe Shop
Machine Shops
Plate & Angle Shop
Template Shop
Plate & Angle Correction Shop
Pump House & Sub Station
Steel Racks
Yard "A C"
Truck Scale
Checkers Office
Yard "B C"
Henson Property Line
Photo Tower
Pipe Storage Space
Oil & Paint Storage
Fuel Oil Tanks
Water Tank
Sewer & Water Bldg.
Main Fire Sta.
Warehouses
SECOND STREET
E STREET
F STREET
Fire Sta.
Compressor House
Tracks
Paint & Oil Shop
FRONT STREET
Transformer House
Marine Buildings
A STREET
Filtration Plant
9 @ 105′ = 945′
210′
5670′
300′
257′
PHILADELPHIA
CHESTER
PENN. R.R.
PHILADELPHIA & READING CHESTER R.R.
SUN SHIP CO.
DELAWARE RIVER
Hog Island Ship Yard
Schuylkill River
LEAGUE ISLAND
NEW YORK SHIP CO.
PENN SHIP CO.
CAMDEN SHIP CO.
CAMDEN

American International Shipbuilding Corporation, Hog Island, Pennsylvania

Fig. 18.—Laying Keel of the First Ship

Street, Philadelphia, and one runs across the river to Billingsport, N. J.

The force at the island at the present time is about 30,000, one-half of whom are at work on the ships, some 9,000 are on operation or maintenance of the plant, and 6,000 are still on yard construction. The yard, however, is practically finished, and when the manufacturing of ships is at its height the total force will run between 30,000 and 35,000. The weekly payroll is now about $1,000,000. Standard union wages are paid on construction work, and the ship workers are paid on the basis established by the so-called "Macy Wage Adjustment Board." There is some piece work and this will be extended as the work progresses.

On September 13, 1917, the date on which the contract was signed, Hog Island was a desolate waste. One week later construction began and went on continuously throughout the winter, so that on February 12, 1918, the first keel was laid and on August 5 the first ship was launched, and at this date, October 5, there are forty other ships under construction and three at the outfitting piers.

Overcoming Some Difficulties

As one looks at the shipyard, practically completed in eleven months, it is hard to realize the difficulties encountered in making it a possibility. Last winter was the coldest on record in Philadelphia, and the frost got into the ground to a depth of 42 inches as compared with 24 inches in an ordinary winter, so that it had to be blasted out with dynamite or thawed out with live steam before the piles could be driven. The thermometer for two months was below freezing point most of the time, and on several nights it went below zero and there was no shelter from the wind which swept across the island. The trenches were continually full of water and ice, and, as a matter of fact, hundreds of men had their feet, hands and ears frozen. It took on an average an hour and a half to get to Hog Island, or three hours each day was spent by most of the men on the cars during the short winter days. The wonder is that during this cold weather any work was accomplished.

The labor turn-over during these trying months was, of course, high, but as winter moderated and transportation improved it decreased, so that at the present time the turn-over is only about 35 percent per month. This is, of course, decidedly higher than it should be, but it is simply typical of what is going on all over the country.

Fig. 19.—What Hog Island Looked Like Before the Coming of the Engineers

Even the best of conditions do not prevent the laborers from migrating. The executives, and in fact the entire office staff, worked with great enthusiasm for uncounted hours during the early days and until they were branded as "thieves, profiteers and grafters," when the spirit broke down and the morale of the organization came near going to pieces.

Little by little, however, as the work progressed, as the yard neared completion and as ships began to take shape and finally the launchings began, criticism had died away, and now unbounded praise has taken its place. The *esprit de corps* has come back and everyone is now doing his best. The organization is complete, the entire enterprise is functioning properly and ships will be manufactured at an unheard-of rate—from two to three each week. This is the programme which was outlined at the start, and it will be lived up to. Already three have been launched and are lying at the outfitting piers, where they are fast nearing completion. There are four 35-ton gantry cranes installed on each outfitting pier and a 100-ton bridge crane has been installed, under which any of the ships can ride with masts in place. The outfitting piers are 1,000 feet long and 100 feet wide, and by dredging out some 6,000,000 cubic yards a 23-foot depth of water is being secured.

Present Condition of Yard

The plant is now in condition to turn out a million and a half deadweight tons of ships per year, and, as one of the engineers on the job has said, "It would be no trick at all to get out two million deadweight tons if we could be assured of the steel and the other supplies necessary."

This million and a half tons of ships calls for half a million tons of steel, for 90,000,000 rivets, for 570 boilers, for 700,000 horsepower of steam turbines, and this material must all come in regular order and in an established sequence. It cannot be done, our critics will say, but it is being done. The capacity of the yard at the present time does not depend on the yard itself, but on the shops elsewhere from which it draws its supplies. All the steel plants in the country are being taxed to their utmost, but it is believed that American ingenuity, American enterprise and American push, together with American loyalty, will solve all these difficulties, and that this fleet of 180 ships will be completed and turned over to the Government before August, 1919, the date upon which they are promised.

Need for New Waterways

THE need of inland waterways, both for commercial development and for the protection of the United States in time of war, is one of the problems that is concerning shipping men at the present time. Effort is being made to create a sea level canal through the short lakes that may connect our deep water intercostal sounds and bays. The latter comprise at least 85 percent of the Atlantic intracostal canal system, and it requires only the deepening of New Jersey, Delaware and Maryland connecting links—a matter of 15 percent of the whole system—to make for the United States the most valuable intracostal waterway in the whole world. The activity of the submarines has revealed to us the folly in our not having long ago developed these inland waterways. Such a development in accordance with the United States Army Engineers' plans would be much more valuable for commerce than the inland waterways of Central Europe. We need wider waterways and more waterways at once.

Classification Society Necessary to the Merchant Marine

(*Continued from page* 674)

sible our increased merchant marine, very wisely recognized this fact, and the law embodies the following provision:

"It [the Shipping Board] shall examine the rules under which vessels are constructed abroad and in the United States, and the methods of classifying and rating same, and it shall examine into the subject of marine insurance .....and ascertain what steps may be necessary to develop an ample marine insurance system as an aid in the development of an American merchant marine."

It is therefore clearly the policy of this government to aid and abet all facilities necessary for the successful operation of a merchant marine. Of vital importance to "an ample marine insurance system" is the encouragement of an American classification society. Without such a society, backed up by both the government and private interests, it will be very difficult to enlist the aid of American insurance companies.

Heretofore the conditions of American shipping have not been such as to encourage the vital collateral function of a successful merchant marine, but now with the United States leading the world in ship construction it becomes the duty of the government and of every patriotic American to support and help upbuild every means necessary to the successful operation of a great merchant fleet.

In the intense rivalry for foreign trade which is bound to ensue at the close of war, this nation must be fully prepared to enter with its own carriers on the seas, backed up by every essential, operated by its own people and aided in every way by government and private support.

Foreign Impressions of an American Seaman

"The exceptional democratic spirit in the British Navy—rather foreign to our own—caused much wonderment," says an American seaman in a recent issue of the *New York Times*. This sailor had previously seen service in the Eastern Atlantic.

"The jolly and carefree attitude of the British seaman is in marked contrast to the sombre 'Spartan' outlook that is characteristic of our men. I was particularly amazed at the size and power of the British Navy, and especially at the radical characteristics of the British ships.

"I visited a number of German prison camps and noted the excellent quarters of the men, their healthy state, and complacent countenances.

"The great welcome given the Americans by the British was very gratifying. The latter did everything in their power to show us a good time, and made us feel at home in the 'mother country,' as they put it. Their general idea of America was rather vague, however. In Edinburgh, where I attended church, the minister offered up a very touching prayer for 'the wild Indians in America.'

"The great number of submarines are ever present, also ever harmless when confronted by efficient lookouts on speedy ships.

"There is very good feeling between Americans and Frenchmen and between Americans and British.

"And, finally, I noted the great confidence and new life which the actions of our men have instilled into those rather wearied by many years of hard war."

Control of the Construction of a 5,000-Ton Deadweight Fabricated Steel Ship—IV

Special Schedule for the Ordering and Installation of Machinery and Equipment—Correlation Between Order and Purchasing Departments

BY FABRICATOR

THE desirable method for handling the machinery and equipment of a fabricated steel vessel would be to have the items delivered to the yard a few days before they were to be installed, allowing, of course, enough time for preparation. This procedure would avoid unnecessary tying up of capital and excessive use of storage space. The procedure requires a consideration of the methods of handling equipment, an estimation of the time for which the building slips are to be tied up with each vessel, and a distribution of workmen.

The policy adopted for this size vessel was that, with the exception of the boilers and engines, installation of the machinery and piping and electrical systems would be started as early as possible. In no way, however, would their installation be allowed to interfere with the progress of the hull erection; the equipment and miscellaneous outfits would be put aboard after launching. The line shafting and bearings would be installed just as soon as the condition of the hull would permit. The boilers, main engines and thrust bearing would not be installed until after launching.

To establish dates for delivery of the various items to the yard, an analysis of the operations was made. As it was necessary to build up a yard organization, the outside man was called in and an estimate of the labor required for the various operations was made at the same time. Complete analysis is given herewith on pages 692 and 693.

Referring to the operation analysis. The estimated number of workmen, as entered, is the number of men who could complete that particular operation in ten hours —that is, the man-hours is ten times the number of workmen in each case. The "days to complete" is an estimate of the maximum time which can be allowed to complete the operations. The time is controlled by the launching and trial trip dates. The "day to start" is an estimate of the earliest day on which any operation can be commenced, and is based on the progress of erection and the condition of adjoining or affected jobs.

The labor estimate was based on schedule of estimated performance on the building slips—thusly:

Operation	Standard	Period Hours	Gang Men
Riveting	500 rivets	10	4
Bolters	200 bolts	10	2
Reamers	1,500 holes	10	1
Chippers and calkers		10	1
Ship fitters	12 tons	10	3

All of these standards were based on the record of previous performances, except that of chipping and calking, which was put up to the judgment of the outside man as each operation came up for consideration.

From this estimate, schedules were figured out covering "Piping and Wiring Installation," "Machinery Installation," "Carpenter and Joiner Work," and "Deck Fittings and Miscellaneous Items" to aid the order clerk and purchasing department when specifying and accomplishing deliveries. Four separate schedules were figured out to allow the order clerk to split up his work. Each schedule controlled all of the items required to complete the installations of the machinery or equipment in its classification.

PIPING AND WIRING INSTALLATION ON NINE 5,000-TON DEADWEIGHT STEEL CARGO SHIPS

Index	Item	Days	Requisition Due	Hulls 87, 88, 89			Hulls 90, 91, 92			Hulls 93, 94, 95		
				Material at Yard	Installation		Material at Yard	Installation		Material at Yard	Installation	
					Started	Completed		Started	Completed		Started	Completed
43	Plumbing	25	Feb. 25	April 26	May 26	June 20	June 28	July 28	Aug. 22	Aug. 30	Sept. 30	Oct. 25
44	Bilge Piping	30	Jan. 28	Mar 28	April 28	May 28	June 1	July 1	Aug. 1	Aug. 11	Sept. 11	Oct. 11
45	Fire Lines	23	Feb. 28	April 29	May 29	June 21	June 31	July 31	Aug. 23	Sept. 3	Oct. 3	Oct. 26
46	Fresh Water Piping	19	Mar. 10	May 10	June 10	June 29	July 12	Aug. 12	Aug. 31	Sept. 15	Oct. 15	Nov. 4
49	Electric Wiring	30	Feb. 25	April 28	May 28	June 28	July 1	Aug. 1	Sept. 11	Sept. 9	Oct. 9	Nov. 9
57	Deck Machinery Piping	47	Feb. 16	April 16	May 16	July 2	June 18	July 18	Sept. 4	Aug. 19	Sept. 19	Nov. 5
50	Heating System	20	Mar. 3	May 3	June 3	June 23	July 5	Aug. 5	Aug. 25	Sept. 8	Oct. 8	Oct. 28
58	Engine and Boiler Room Piping	47	Feb. 16	April 16	May 16	July 2	June 18	July 18	Sept. 4	Aug. 19	Sept. 19	Nov. 5
62	Sea Connections	15	Feb. 20	April 20	May 20	June 4	June 21	July 21	Aug. 5	Aug. 22	Sept. 22	Oct. 7

MACHINERY INSTALLATION SCHEDULE ON NINE 5,000-TON DEADWEIGHT STEEL CARGO SHIPS

Index	Item	Days	Requisition Due	Hulls 87, 88, 89			Hulls 90, 91, 92			Hulls 93, 94, 95		
				Material at Yard	Installation		Material at Yard	Installation		Material at Yard	Installation	
					Started	Completed		Started	Completed		Started	Completed
26	Stern Tube	3	Jan. 18	Mar. 18	April 18	April 22	May 21	June 21	June 24	July 21	Aug. 21	Aug. 24
27	Bearing and Shafting	8	Jan. 25	Mar. 25	April 25	May 3	May 28	June 28	July 6	Aug. 7	Sept. 7	Sept. 15
28	Propeller and Shaft	2	Feb. 28	April 30	May 30	June 1	July 2	Aug. 2	Aug. 4	Sept. 4	Oct. 4	Oct. 6
30	Fresh Water Tanks	4	Mar. 5	May 5	June 5	June 9	July 7	Aug. 7	Aug. 11	Sept. 10	Oct. 10	Oct. 14
55	Auxiliary Machinery	35	Feb. 20	April20	May 20	June 25	June 21	July 21	Aug. 25	Aug. 22	Sept. 22	Oct. 27
53	Boilers	15	Mar. 10	May 10	June 10	June 25	July 12	Aug. 12	Aug. 27	Sept. 15	Oct. 15	Oct. 30
54	Engines	20	Mar. 10	May 10	June 10	June 30	July 12	Aug. 12	Sept. 1	Sept. 15	Oct. 15	Nov. 4
56	Thrust Shaft and Bearing	10	Mar. 12	May 12	June 12	June 22	July 14	Aug. 14	Aug. 24	Sept. 17	Oct. 17	Oct. 27
59	Deck Machinery	15	Mar. 5	May 5	June 5	June 20	July 8	Aug. 8	Aug. 23	Sept. 11	Oct. 11	Oct. 26
60	Induced Draft	6	Mar. 10	May 10	June 10	June 16	July 12	Aug. 12	Aug. 18	Sept. 15	Oct. 15	Oct. 21

Operation Analysis and Labor Estimate for One 5,000-Ton Deadweight Fabricated Steel Ship

LAUNCH 60th DAY AND DELIVER 90th AFTER LAYING KEEL

Item	Number of Pieces	Weight, Tons	Operations	Men	Days to Complete	Day to Start
1 Flat Plate Keel (incl. Straps)	15	29.4	Laying on Keel Blocks Fitting and Bolting-up (700) Reaming Riveting (2,700) Calking	9 18 2 18 6	1	1st
2 Vertical Keelson	6	17.9	Placing on Flat Plate Keels Fitting and Bolting-up (600) Reaming Riveting (2,800) Calking	3 6 2 18 3	1	1st
3 Bottom Shell Garboard to Bilge, both included	202	176.0	Placing on Ways Fitting and Bolting-up (21,000) Reaming Riveting (62,000) Calking	45 105 41 496 20	5	1st
4 Stem	2	2.6	Placing Bolting and Fitting (150) Reaming Riveting (540) Calking	3 2 2 4 2	1	6th
5 Stern Frame	1	9.5	Placing Fitting and Bolting (500) Reaming Riveting (2,000) Calking Boring	3 6 3 16 4 6	1	7th
6 Floors and Intercostals	600	219.5	Placing Fitting and Bolting (14,000) Reaming Riveting (46,000) Calking	63 140 30 368 5	7	8th
7 Tank Top Plating (includes Doublers, Manhole and Heater, Rings and Covers)	88	132.6	Placing Fitting and Bolting (7,000) Reaming Riveting (30,000) Calking	36 70 10 200 15	6	12th
8 Bulkheads	373	123.1	Placing Fitting and Bolting (6,000) Reaming Riveting (24,000) Calking	30 60 16 200 5	4	19th
9 Frames (includes Channel Web and Angle Frames and Pillar)	289	242.0	Placing Fitting and Bolting (12,500) Reaming Riveting (50,000) Calking	63 140 33 400 3	7	25th
10 Shaft Foundation	18	2.9	Fitting and Bolting (150) Reaming Riveting (600) Calking	2 1 8 3	3	17th
11 Shaft Alley	86	38.1	Placing Fitting and Bolting (3,000) Reaming Riveting (8,000) Calking	9 30 4 64 6	6	30th
12 Second Deck Beams and Girders (includes Deep Tank Top Intercostals)	81	17.5	Placing Bolting (900) Reaming Riveting (4,800)	6 8 3 36	3	30th
26 Stern Tube	3	.....	Fitting and Bolting Riveting Calking	4 4 1	3	10th
27 Line Shafting and Spring Bearings	.....	.....	Machining and Fitting	32	8	17th
28 Shaft and Propeller	2	.....	Machining and Fitting	24	2	51st
29 Auxiliary Machinery Foundations	311	26.3	Placing Fitting and Bolting (1,500) Reaming Riveting (6,000) Calking	9 15 4 48 14	11	55th
30 Fresh Water Tanks	.....	.....	Fitting and Bolting Reaming Riveting Calking	6 2 64 14	4	58th
31 Mast Foundations	80	14.5	Placing Fitting and Bolting (1,000) Reaming Riveting (4,000) Calking	6 10 3 32 3	6	50th
32. Cementing	.....	.....	Cementing	40	14	45th
33 Bottom and Shell	.....	.....	Chipping Painting	84 48	15	35th
34 Chocks, Bitts, Cleats, Mooring Rings, etc.	.....	.....	Fitting and Bolting Reaming Riveting	41 3 4	12	53rd
35 Derricks	.....	.....	Rigging	18	10	71st
36 Vents and Gear	32	.....	Fitting and Bolting Reaming Riveting Machining	16 2 4 6	11	63rd
37 Gun Platforms	98	10.1	Fitting and Bolting Reaming Riveting (2,000) Calking	5 2 16 2	15	46th
38 Masts	.....	.....	Rigging	6	5	66th
39 Skylights	.....	.....	Fitting and Bolting	10	10	66th
40 Wood Decks	.....	.....	Carpentering Calking	48 40	13	64th
41 Deck Shelters and Railings	.....	.....	Fitting and Bolting Reaming Riveting	42 4 16	10	65th
42 Chart House, Bridge, Wheel House and Wireless Room	.....	.....	Fitting and Bolting Reaming Riveting	22 6 16	20	71st
43 Plumbing	.....	.....	Fitting	104	25	47th
44 Bilge Piping	.....	.....	Fitting	96	30	20 h
45 Fire Piping	.....	.....	Fitting	105	23	50th
46 Fresh Water Piping	.....	.....	Fitting	35	19	62nd
47 Ladders and Platforms	.....	.....	Machining	80	13	58th

	Item	Number of Pieces	Weight, Tons	Operations	Men	Days to Complete	Day to Start
13	Upper Deck Beams	22	101.1	Placing Bolting (6,000) Reaming Riveting (22,000)	27 60 15 176	4	33rd
14	Shell Plating (Strakes F-G-H-J and L(	180	271.4	Placing Fitting and Bolting (18,000) Reaming Riveting (56,000) Calking	72 180 40 448 101	7	30th
15	Second Deck Plating (includes Deep Tank Top)	51	9.2	Placing Fitting and Bolting (1,000) Reaming Riveting (4,000) Calking	3 10 3 32 15	2	32nd
16	Upper Deck Plating (includes Doublers)	106	118.6	Placing Fitting and Bolting (6,000) Reaming Riveting (24,000) Calking	27 60 20 200 25	6	37th
17	Bulwarks (includes Plating and Stiffeners)	179	36.0	Placing Fitting and Bolting (2,000) Reaming Riveting (8,000) Calking	9 20 5 64 16	4	40th
18	Fo'cstle and Poop Structure Framing, Plating	78	72.2	Placing Fitting and Bolting (2,600) Reaming Riveting (13,000) Calking	18 26 10 120 4	3	43rd
19	Bridge Deck House (Framing and Decking and Side Plating)	88	54.0	Placing Fitting and Bolting (2,400) Reaming Rivetting (12,000) Calking	15 24 10 96 30	3	43rd
20	Hatch Coamings	248	40.7	Placing Fitting and Bolting (15,000) Reaming Riveting (9,000) Calking	9 15 6 72 8	4	45th
21	Engine and Boiler Casings and Coal Chute	178	27.3	Placing Fitting and Bolting (1,000) Reaming Riveting (5,000)	9 10 3 40	5	38th
22	Galley, Mess Room and Cold Storage Casings	131	8.9	Fitting and Bolting (800) Reaming Riveting (3,000) Calking	8 2 24 4	2	45th
23	Engine and Boiler Foundations	85	29.7	Placing Fitting and Bolting (2,000) Reaming Riveting (7,000) Calking	9 20 5 60 12	6	18th
24	Boat Deck Houses	61	19.5	Placing Fitting and Bolting (1,000) Reaming Riveting (4,000) Calking	6 10 3 32 8	4	50th
25	Deck House Bulkhead	467	57.2	Placing Fitting and Bolting (2,000) Reaming Riveting (9,000) Calking	12 20 6 72 14	8	46th

	Item	Number of Pieces	Weight, Tons	Operations	Men	Days to Complete	Day to Start
48	Cabin Joiner Work			Joining Carpentering	80 100	20	56th
49	Electric Wiring			Wiring	120	30	50th
50	Heating System			Fitting	96	20	56th
51	Davits and Fittings			Rigging	144	20	60th
52	Cargo Battens and Clips			Carpentering	100	10	65th
53	Boilers			Rigging Pipe Fitting Machining Helping	40 4 10 20	15	63rd
54	Engines			Rigging Pipe Fitting Machining Helping	36 10 90 90	20	63rd
55	Auxiliary Machinery			Rigging Pipe Fitting Machining Helping	36 36 90 90	35	40th
56	Thrust Shaft and Bearing			Rigging Pipe Fitting Machining Helping	36 5 12 12	10	65th
57	Deck Machinery and Steam Exhaust Piping			Pipe Fitting	24	47	37th
58	Engine and Boiler, Steam and Exhaust Piping			Pipe Fitting	208	47	37th
59	Deck Machinery			Rigging Machining Helping	54 25 50	15	58th
60	Induced Draft			Rigging Pipe Fitting Machining Helping	48 50 24 24	6	64th
61	Engine and Boiler Room Gratings, Floors and Ladders			Rigging Pipe Fitting Machining Helping	12 4 18 18	20	58th
62	Sea Connections			Pipe Fitting Machining Helping	30 48 48	15	40th
63	Stack and Breachings			Rigging Helping Machining	30 48 48	10	70th
64	Lagging and Coverings			Pipe Fitting	18	30	50th
65	Preparation			Carpentering Rigging	20 15	7	52nd
66	Launch			Carpentering	20	1	60th
67	Hotel Equipment					10	70th
68	Trial					5	82nd
69	Delivery					1	90th

CARPENTER AND JOINER WORK AND EQUIPMENT ON NINE 5,000-TON DEADWEIGHT STEEL CARGO SHIPS

Index	Item	Days	Requisition Due	Hulls 87, 88, 89			Hulls 90, 91, 92			Hulls 93, 94, 95		
				Material at Yard	Installation		Material at Yard	Installation		Material at Yard	Installation	
					Started	Completed		Started	Completed		Started	Completed
40	Wood Decking	13	Mar. 11	May 11	June 11	June 26	July 13	Aug. 13	Aug. 26	Sept. 16	Oct. 16	Oct. 29
48	Cabin and House Joiner Work	20	Mar. 5	May 5	June 5	June 25	July 7	Aug. 7	Aug. 27	Sept. 10	Oct. 10	Oct. 30
52	Cargo Battens and Clips	10	Mar. 13	May 13	June 13	June 23	July 15	Aug. 15	Aug. 25	Sept. 18	Oct. 18	Oct. 28
65	Preparation	7	Feb. 29	April 29	May 29	June 5	June 31	July 31	Aug. 7	Sept. 7	Oct. 3	Oct. 10
67	Hotel Equipment	10	Mar. 18	May 18	June 18	June 28	July 19	Aug. 19	Aug. 29	Sept. 22	Nov. 22	Nov. 1

DECK FITTINGS AND MISCELLANEOUS ITEMS ON NINE 5,000-TON DEADWEIGHT STEEL CARGO SHIPS

Index	Item	Days	Requisition Due	Hulls 87, 88, 89			Hulls 90, 91, 92			Hulls 93, 94, 95		
				Material at Yard	Installation		Material at Yard	Installation		Material at Yard	Installation	
					Started	Completed		Started	Completed		Started	Completed
32	Cementing	14	Feb. 25	April 25	May 28	June 18	June 26	July 26	Aug. 9	Aug. 27	Sept. 27	Oct. 11
33	Painting Bottom	15	Feb. 14	April 14	May 14	May 29	June 16	July 16	July 31	Aug. 17	Sept. 17	Oct. 2
34	Chocks, Bitts, etc	12	Feb. 25	April 25	May 25	June 6	June 27	July 27	Aug. 8	Aug. 29	Sept. 29	Oct. 11
35	Derricks	10	Mar. 18	May 18	June 18	June 28	July 20	Aug. 20	Aug. 30	Sept. 23	Oct. 23	Nov. 2
36	Vents and Gear	11	Mar. 10	May 10	June 10	June 21	July 12	Aug. 12	Aug. 23	Sept. 13	Oct. 13	Oct. 26
38	Masts	6	Mar. 13	May 31	June 13	June 19	July 15	Aug. 15	Aug. 21	Sept. 18	Oct. 18	Oct. 24
39	Skylights	10	Mar. 13	May 13	June 13	June 23	July 15	Aug. 15	Aug. 25	Sept. 18	Oct. 18	Oct. 28
41	Deck Shelters and Railings	10	Mar. 12	May 12	June 12	June 22	July 14	Aug. 14	Aug. 24	Sept. 17	Oct. 17	Oct. 27
47	Ladders and Platforms	13	Mar. 5	May 5	June 5	June 18	July 7	Aug. 7	Aug. 20	Sept. 10	Oct. 10	Oct. 23
51	Davits and Fittings	20	Mar. 7	May 7	June 7	June 27	July 9	Aug. 9	Aug. 29	Sept. 12	Oct. 12	Nov. 2
61	Engine and Boiler Room Gratings, etc	20	Mar. 6	May 6	June 6	June 26	July 8	Aug. 8	Aug. 28	Sept. 11	Oct. 11	Oct. 31
63	Stack and Breeching	10	Mar. 17	May 17	June 17	June 27	July 19	Aug. 19	Aug. 29	Sept. 22	Oct. 22	Nov. 2
64	Lagging and Coverings	30	Feb. 26	April 27	May 27	June 27	June 29	July 29	Aug. 29	Aug. 1	Sept. 1	Oct. 1

The date for delivery of the requisitions to the purchasing department and for delivery of material at the yard was fixed and rigidly adhered to. The order clerk inserted the delivery dates on the requisitions, and the purchasing department, which was responsible for deliveries, was provided with copies of the schedules. As this phase was "up to" the men in the purchasing department, they had the right to call for immediate action, on the part of the order clerk, on such items as were difficult to secure, or as required special attention.

Since there was nothing of especial interest about the requisitions or purchase orders, they will not be covered in detail here. The method of using them may be suggested, however. The order clerk was under the naval architect, who approved all requisitions before they went to the purchasing agent. The requisitions bore the ordinary accounting information, i. e., the quantity or number of items required, the description and specifications in a general way, with just enough technical information to allow the purchasing agent to submit an intelligent request for quotations. The purchasing department maintained the usual follow-up on its requests, and with the quotations closed they would be submitted to the naval architect for approval and recommendations. A copy of the purchase order was sent to the naval architect and the quotations were returned by him to the purchasing agent.

The yard was kept posted on the receipt of all material, except steel, by the regular receiving report, made out by the receiving clerk after it had already passed through the hands of the order clerk, who inserted the hull number or job number on which the item was to be used. No special features were incorporated in this report. In fact, "red tape" was whitewashed wherever possible. The method of checking steel receipts will be covered in a subsequent issue.

Test of Rivetless Ships

Some interesting particulars relative to the test vessel of welded construction which is being built at the Central Shipbuilding Plant, Newark, N. J., for the Emergency Fleet Corporation are worthy of being reproduced. It has been necessary to design a ship to suit the material available without encroaching on that needed for the regular ship construction at Newark, and hence the hull will have the outline dimensions and strength conforming to the ships there building. The work will, however, be carried out at a site apart from the slipways, so as not to interfere with the ordinary work of the yard.

Briefly, the programme is to assemble a hull rapidly by spot welding, so that the structure becomes a house in which the work may go forward in all weathers and also at night. The spot welds are to be about 10 inches apart, so that the structure is sufficiently strong to hold its shape while the work is completed by arc-welding all seams to ensure strength and to render the work watertight. Three-quarters of the entire structure will be welded, and the other quarter riveted in the ordinary way, so that the tests of strength will afford a basis of comparison. Moreover, apart from strength considerations, it is recognized that welding offers a great field for lightening a ship, and it is hoped that ultimately 10 percent of the steel may be eliminated. The problems of fitting in place the parts of a hull are almost wholly problems arising out of the necessity to make a number of little holes, made in a plate by one man at one time and one place, fit a number of little holes made by another man at another time and another place. When the holes are left out of the material, all parts fit, and the creeping and kindred problems so perplexing to the shipbuilder disappear.

The primary test of the completed hull will consist of filling with water and shifting the points of support. This will be carried out under continual and close scrutiny, and as one-quarter of the whole will be riveted there will always be a gage of comparison between the two systems of construction. The two systems will also be tested by subjecting each to bumping with rams and in various other ways, so that as far as is possible, apart from the conclusive tests of actual sea service, everything will be done in order to enable the shipbuilding authorities to form an opinion as to the relative advantages and disadvantages of welding as compared with riveting.

Structural Steel Standardized Cargo Vessels

How Quantity Production Was Met—Use of Structural Steel Expedient—Layout of Yard

BY HENRY R. SUTPHEN*

THE war brought about a new type of ship construction, commonly referred to as "fabricated ships," which only in part describes the new method that we have had to solve in manufacturing structural steel cargo vessels at the Newark Bay shipyard.

Our problem was one of quantity production, thereby necessitating thorough standardization of design, ship material, fabrication and assembly.

By referring to the newspapers during the months of March and April, 1917, before and after we entered the war, one will note with interest how much discussion there was over the problem of new ship construction made absolutely imperative by our entrance into the great world war. Some suggested large numbers of small wooden ships of 1,600 tons burden, with high speed. Others demanded larger ships, and many agreed that wood was the only material available to construct the emergency fleet.

In the fall of 1916 the Submarine Boat Corporation had completed for the British Admiralty 550 submarine chasers which were built of wood, the hull material having been fabricated in its Bayonne, N. J., shops and assembled into the finished boats at Montreal and Quebec, Canada. This was the first large boat manufacturing project ever attempted and was successfully completed ahead of contract time; it was the "model experiment" for the far greater task we are now engaged in of furnishing to the United State Shipping Board Emergency Fleet Corporation one hundred and fifty 5,000-ton steel cargo ships.

Why Structural Steel Was Made

Our experience in obtaining the proper quality of material for wooden boat construction, an art that had practically disappeared, made us feel certain that the large tonnage desired in wooden ships would be most difficult to obtain, not only on account of material, but also because of the shortage in wooden shipbuilding labor. Further, while wood could be fabricated into boat material, nevertheless the material would not stay put like steel, due to shrinkage, checking and rot.

Upon investigation we learned that the output of ship steel for months to come had already been allotted to the established shipyards for merchant work then under way and for naval requirements. We therefore recommended to the United States Shipping Board Emergency Fleet Corporation in April, 1917, that in place of wood we be permitted to submit a plan for manufacturing steel ships to be built with the ordinary commercial structural steel as had been employed in building our skyscrapers, bridges and tanks from which America had obtained such a reputation in steel construction; and, on account of the great emergency and the demand for a large number of ships, we further suggested that we be permitted to manufacture ships and not build them one at a time.

Our plan called for utilizing the large number of bridge and structural steel shops throughout the country which were not then busy with commercial work and which could be employed in fabricating steel shapes and plates from accurate drawings and patterns which we would supply. On account of using unclassified steel, we suggested that we compete in size of ship with the then proposed wooden vessel of 3,500 tons deadweight capacity, but as we progressed in the details of design and construction it was found possible to increase the deadweight capacity and still retain standardization in design and material to 5,000 tons, which is the size of the ship we are now producing in quantity. This size was fixed for other reasons. An analysis of pre-war merchant shipping disclosed the fact that the average commercial cargo carrier ranged between 4,000 and 5,000 tons with a full load speed of 9 knots. It was therefore believed that a 5,000-ton craft, able to make 10½ knots per hour, would be preferable and probably prove a desirable type for service in the years to come. Further, and of no less importance, careful investigation showed that the unit features of a 5,000-ton ship, fabricated at more or less distant outlying plants, would utilize freight car capacities to their fullest and most economical extent and still carry out the plan of having as many rivets as possible driven at the fabricating shops. A total of 427,000 rivets is required to be driven for one of these hulls, and of this total over 100,000 are driven at the fabricating plants, where the work is done on a much more economical basis than in the shipyard. For illustration, the smokestacks were so designed that their maximum diameter came within the width of an ordinary gondola car, permitting the stacks to be shipped completely assembled. The floors with intercostals were assembled in groups of three, the ordinary 36-foot flat or gondola car carrying six sets of floors, which, when loaded, kept within the railway clearance. It was recognized at the start that the railroads would be heavily burdened, and, as a very wide region would have to be drawn upon to furnish material, it was absolutely essential that the car space should be made the most of, so that the fewest possible carriers would be needed to maintain a steady flow of supplies to the assembly yard on Newark Bay.

Eliminating Curves in the Design

Our problem was first to use commercial structural shapes and plates that could be had in large quantities, and design the ships so that these could be assembled with a minimum of alteration through bending, and, next, that the plans should be so developed that the bridge builder and the structural shops should have no difficulty in reading the drawings and adapting their experience and equipment to the fabrication of the parts for ship construction. The naval architect had to speak and draw in terms familiar to the great army of structural steel workers, requiring some radical modifications in the matter of classification details, and imposing rather pronounced departures from the ordinary shipshaped models, in order that the materials at hand might be incorporated in the most efficient manner for maximum production and accuracy of fit. In brief, this necessitated the elimination of curves and the substitution of straight lines and angles wherever possible.

The decks are without camber and generally without sheer, the sides throughout the length of the parallel body are perpendicular; the bottom is flat and is merged with the sides by a short and abrupt curved bilge. By eliminat-

* Vice-president Submarine Boat Corporation.

ing the deadrise characteristics of the vessels it was possible to adopt a uniform size of floor throughout the parallel body and to have recourse to longitudinals which would all be of the same height. Forward and aft of the parallel body the model subscribes with reasonable closeness to that of the accepted design of ocean-going carriers.

As quantity production was the keynote in building these ships, it was essential that the main propelling machinery should be of types capable of being manufactured in quantity. Therefore, watertube boilers were chosen with reduction gear turbines. The boilers are of the Babcock & Wilcox make with a total heating surface of 5,800 square feet, operated with coal or fuel oil under natural draft. The propelling machinery consists of a geared Westinghouse turbine capable of developing 1,500 shaft horsepower, turning a 15½-foot, 4-bladed screw at 90 revolutions per minute. The turbine is connected to the propeller shaft by a helical, double reduction gear with a ratio of speed reduction of 40 to 1. The steam consumption of the turbine when operating at full power should not exceed 12.5 pounds per shaft horsepower.

The storage capacity for fuel oil is 660 tons, carried in the double bottom, which will be sufficient to operate the vessel 7,000 miles.

The ships are fully equipped with all necessary auxiliaries and deck machinery, with comfortable quarters for a crew of 60 men, including 22 men for military operations. Like all other ships building for the Emergency Fleet Corporation, the equipment is complete in every detail.

Commercial Shapes Used Advantageously

Referring to the fabrication and assembly of these ships, which undoubtedly is of the greatest interest to our members, the total weight of structural steel required for one of these ships is 1,564 tons, 462 tons being in shapes and 1,102 tons in plates. The only ship sections used in the design were a few bulb angles at both ends, amounting to 1½ percent of the total weight, or 23 tons. Under our contract all drawings were to be approved by both the American Bureau of Shipping and Lloyd's Register. This meant that, wherever in any particular the rules of the two societies differed, we had to adopt the more stringent rule, and this resulted in a heavier ship than would have obtained by classification in one society. Notwithstanding the increase in weight between these ships and those built with ship classification steel, it has been demonstrated that commercial structural shapes were used advantageously and did greatly relieve the steel mills from furnishing classification ship material.

Getting Out the Detail Drawings

Ninety-six percent of the total weight of the hull was fabricated at outlying establishments. Twenty-eight steel mills supplied material to 56 fabricating plants, not to mention the contributive labors of 200 foundries, machine, pipe, joiner and equipment shops which figure more or less in the building of a cargo carrier. The fabricating shops are scattered from Wisconsin to Massachusetts and as far south as Virginia, and, inasmuch as the parts are fabricated in such a large number of different shops and as the individual parts must be interchangeable, one of the first considerations was to make necessary provision for giving the information to the fabricating shops in such a manner as to insure accuracy of work and speed of production.

It was the bridge engineer working in conjunction with the naval architect who properly interpreted the details of ship fabrication into the language of the bridge shops, thereby permitting the structural shops to fabricate the complicated ship material with the tools and facilities they had in hand, an operation that many old-line shipbuilders question could be carried out successfully. So far as the straight parts of the parallel middle body, flat tank tops and flat decks were concerned it was an easy matter. It was simply a case of making detail drawings exactly as they would be made for a railroad bridge, giving definite location by dimension of every hole ,rivet and each piece of steel. In all some 330 drawings were made of details of hull fabrication. From these drawings all the steel was ordered from the mills exactly to the length required. In the molded portion of the ship, however, the problem became more complicated to the bridge engineer, as this section of the shell could not be mathematically developed. Such plates and shapes were developed full size on the mold loft floor, reproduced on template paper, having all rivet holes punched in them on proper gage lines and for a matter of record carefully measured up and detailed to dimension on individual drawings. Even with complete drawings it was difficult for the fabricating shops to reproduce the plates on account of the edges and gage lines being curved. These lines could only be located by dimensioning a series of points on the curves.

Overcoming Some Minor Difficulties

As we could not count upon two men springing a batten and getting the same shape between points, we overcame this phase of the problem by sending templates of the shell plates in the molded sections to the fabricating companies. These templates, made on template paper approximately 1/32-inch thick, were direct copies of the original template developed on the mold loft floor. A difficulty was experienced in the shrinkage and expansion of these templates, and, to insure the change of shape of the templates causing no misfits, each template was marked before being sent out with certain dimensions. To begin with, the paper used is fairly heavy fabroid material, which has a rather low coefficient of expansion. It was then marked and cut in accordance with the development on the scriveboard, and rivet holes, etc., were laid out upon the paper, spaced and dimensioned with great accuracy.

Checking Templates Against Drawings

The correct dimension for the length of the template, also the correct dimension for width at each end, was painted on with arrows indicating exactly where these dimensions were taken. In addition to this, a straight line was scratched the full length of the template approximately at the centerline. The shop receiving this template was requested, in all cases before using it, to measure it and make certain that the template, as they used it, was correct to the check dimensions given. They were also requested to test the straight line scratched on the template with a straight edge. When, as was very frequently the case, they found that the dimensions did not check or that the line was not straight, they were required to bring it to shape either by dampening it or drying it, as the case might be. There still remained, of course, the possibility that when a template had been expanded by dampening and stretching, the expansion might have taken place all at one section of the plate rather than throughout its length. As it was possible for this to happen, neither checking the dimensions on the template nor checking the straight line would detect the error. To overcome this we insisted that the fabricators check their templates against the detailed drawings which were furnished them. Inasmuch as the local steel tapes determined the measure of

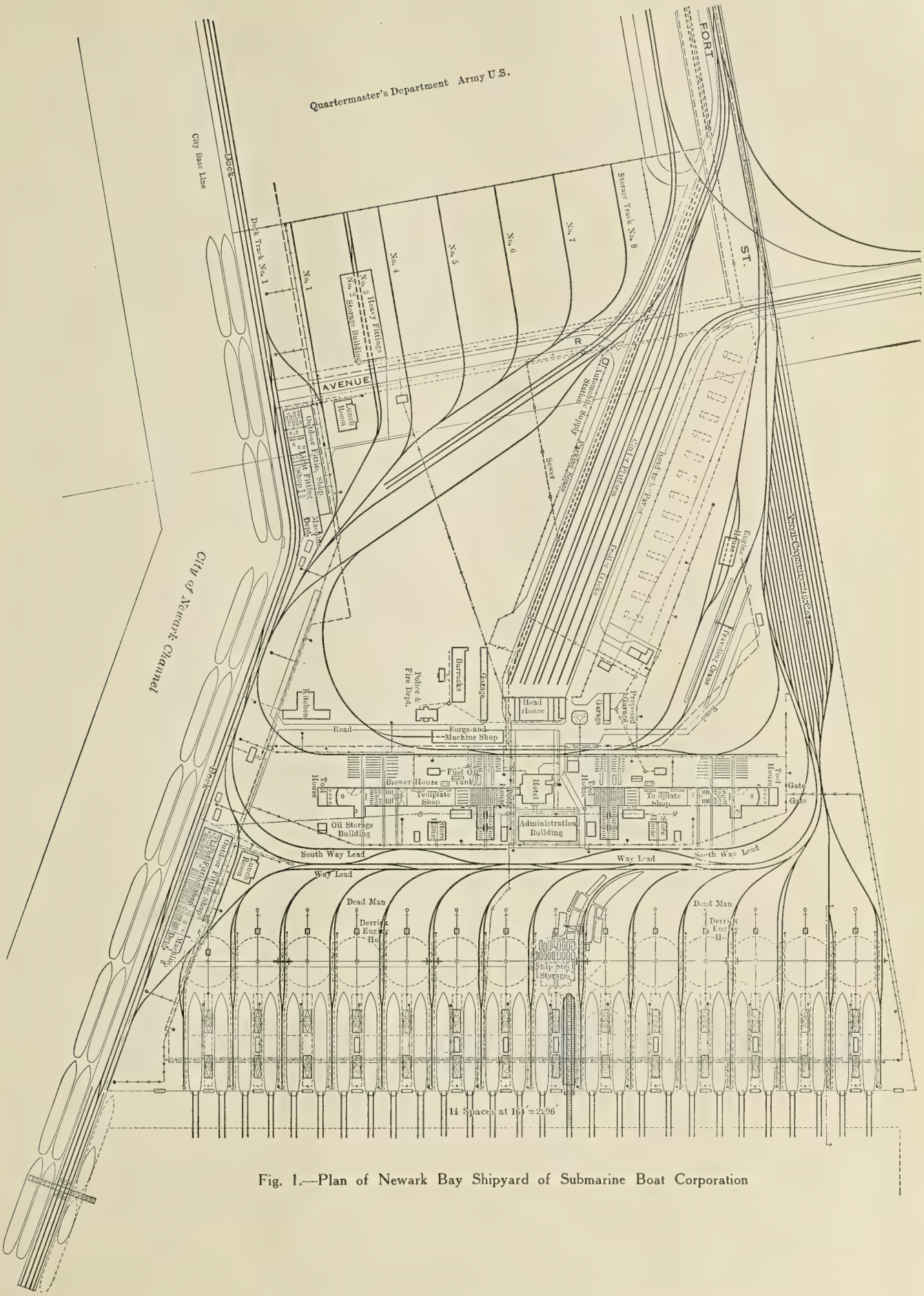


Fig. 1.—Plan of Newark Bay Shipyard of Submarine Boat Corporation

this variation, it was of prime importance that every tape at each and all of the outside works should be uniform.

A single tape was selected for the Newark Bay shipyard where the original templates and drawings were laid down on the mold loft floor, and with this master tape every other tape to be used was compared and carefully calibrated, and a coefficient, plus or minus, prescribed in each case. In this way it has been entirely practicable to insure dimensional agreement not only within the different departments of the Newark Bay shipyard, but similarly within the different departments of every outlying contributive establishment.

This seemed a large amount of checking, but it must be remembered that in each case this had to be done only once, as the majority of shops, after getting their template exactly as required, used it to lay out one steel plate or section which was used as a template for all duplicate operations. A tolerance of 1/16 inch was allowed on all punching, this being the amount of reaming that is done when the material is being erected.

Structural Workers Drive Tight Rivets

Not only is the hull material all fabricated outside, but also the material for machinery installation, such as piping, valves and innumerable fittings. The piping comes bent, with flanges attached, to exact shape, requiring only assembly in the ships. All joiner work and wood sheathing is fabricated in a shop at Detroit, Mich., and shipped to the yard in complete ship sets, and, as it is received completely finished, painted, varnished, and with hardware attached, it is merely a matter of assembly when the ship is ready to receive it.

Before the work started, the idea of fabricating ships on such a large scale was further questioned, on the ground that the structural steel worker could not drive a tight rivet and that his work would not be satisfactory nor pass inspection. Quite the contrary has been the result, as the work has been entirely satisfactory, equal in every respect to work done in the established shipyards, although the question of labor has always been a most difficult problem and could only be obtained by a system of training which has been very thoroughly developed. Over a thousand skilled workmen a month are being turned out by our training department.

Success Due to Layout of Yard

Our success is in no small part due to the layout of the shipyard. As the plan view shows, there are twenty-eight building ways, occupying a waterfront space of substantially one-half mile. Electrically operated derricks, each having a maximum lifting capacity of three tons, are placed between alternate ways and arranged with a reach which will enable them to deal with the materials for a pair of ships. Eighteen miles of railway track insure a steady flow of steel and other material by the shortest possible routes to the points of incorporation in the ships when on the ways or at the fitting-out dock, the latter having a length of nearly one mile, where twenty-two vessels can be berthed at one time, served by a 400-ton gantry crane with a lifting capacity of fifty tons. By an overhead structure, electric and steam cranes serve for minor lifts and place on board the ships directly from adjacent storehouses the equipment and material with the least amount of handling.

Between each companion pair of building slips and beneath the tower derricks is located an administrative building for the superintendent and foreman in charge of the two ships. Within this structure is kept a complete set of plans and all other necessary data. With the exception of the rivet forges, which have their blowers operated electrically, all of the other power tools are driven by compressed air supplied from seven direct connected electrically operated compressor plants.

The fabricating plant at the shipyard is divided into two sections, the north and south shops, as shown on the plan, where bending floors are located, also punch shops, rolls and forges. The bending floors are fed from eight furnaces, all the curved sections fore and aft being bent on these floors. These shops fabricate 4 percent of the total weight of the hull. The plates to be rolled are shipped flat from the fabricators, punched and shaped to size, and rolled at the shipyard. As many as 175 tons of plates have been rolled in a single day. Furnace plates, of which there are only eighteen, requiring hot forgings, are pressed hot in hydraulic presses at outside fabricating shops and shipped to the yard in blank form, where they are punched and worked to size to correct metal templates.

Exclusive of the rolled plates, these shops with their limited equipment have delivered 460 tons of frame material per week, working night and day shifts, which, we believe, will compare most favorably with other shipyards.

Rivets and Men and Ships

Rivet driving being the barometer of production has gradually increased from 30,000 per day during July to about 75,000 a day for October, with an average drive of thirty-two rivets per gang hour. As the men become more experienced and accustomed to their task, we believe that a higher average hourly rate will be obtained.

For the last two months we have employed an average of about 12,000 men and have been assembling at the rate of six ships per month; 18,000 men will ultimately be required to fully man the yard, when a production of twelve ships per month may be expected.

We are a little over a year old in our enterprise, having broken ground on September 14, 1917, and during this period, through an unusually severe winter, we have completed the shipyard, delivered our first ship, the *Agawam*—classed A1 by both the American Bureau of Shipping and Lloyds, this being the first fabricated ship built of structural steel to be delivered—and launched in all fifteen ships, which conclusively proves the soundness of the fabricated construction and how this method which we have employed has been the only one that could have been followed in the emergency to build the bridge of ships to Pershing and victory.

The Largest Motor Boat

The largest and most powerful motorship yet produced anywhere was, in September, put through her speed trials on the Clyde. This is the twin-screw, Diesel-engined *Glenapp,* of 10,000 tons deadweight carrying capacity. The total engine power of 6,600 horsepower is developed in two sets of 8-cylinder, four-cycle engines furnished by the Burmeister & Wain (Diesel) Oil Engine Company, Glasgow. The vessel herself was built by Messrs. Barclay, Curle & Company, Whiteinch, who previously were associated with the Burmeister & Wain works, and were pioneers in Great Britain in the matter of motorships. All the engine room auxiliaries of the *Glenapp,* also all deck machinery, including the steering gear, are electrically driven, the power being generated by two auxiliary Diesel sets in the engine room. A small oil-fuel boiler supplies steam for heating and cooking systems and for fire-extinguishing purposes. The oil fuel is carried in the vessel's double bottom, the space generally occupied by side and cross coal bunkers being thus available for cargo.

The Steel Ship and Oxy-Acetylene Welding

Autogenous Welding Decreases Strength of Steel—Behavior Under Heat—Restorative Measures

BY J. F. SPRINGER*

THE present necessity to construct quickly a vast total of tonnage has doubtless been the chief thing that has brought the newer methods of welding so prominently to the attention of shipbuilders and the government. The oxy-acetylene process has been winning its way steadily for the past decade, particularly in connection with steel plates. I direct attention to steel cylinders used in the transportation of gases under pressure and to steel barrels employed as containers liable to rough handling. The welding work here is analogous to that required in a ship's side.

However, not all operators of the torch understand what happens to the steel and what are the possibilities of restoring any damage to the quality incident upon the application of gas and electric welding. A good many are probably ignorant that there is any damage to quality that needs rectification. Let us then consider this matter.

Behavior of Steel When Heated

All normal, unhardened steel consists of crystals or grains built up of alternate laminations of cementite (Fe_3C) and iron, with or without separating films either of iron or of cementite. In steels containing less than 0.85 or 0.90 percent of carbon—such as are practically all steels used for ship plates—there is a honeycomb of pure iron. The spaces or cells in the honeycomb are occupied by crystals, or grains of interleaved layers of iron and cementite. Steels containing a higher carbon percentage —tool steels—have a honeycomb of cementite; the crystals are the same as before. For steel at the dividing percentage, there is no honeycomb; the crystals are the same, but they are now in actual contact. The interleaved layers of pure iron and cementite constitute a material (it is not a chemical combination, being non-homogeneous) which has been named *pearlite* by Professor Henry M. Howe, of Columbia University. For ship construction, steel having the first type of structure—a honeycomb of pure iron filled with pearlite crystals—is used.

Behavior of Crystals During Heating

The importance of this information in connection with oxy-acetylene welding centers on the behavior of the crystals of pearlite during a rise of temperature. As the temperature rises from the normal, everyday point, nothing of importance occurs until the steel has passed above a black heat. About *medium cherry red* (1,274 degrees F.), the grains begin to grow. As the temperature goes on up, the grain size continues to increase. Probably there is no substantial cessation of growth until the steel is at or near the melting point. If the heating is halted at any point of temperature, the growth will also halt. When the steel is cooled, whether suddenly or slowly, the enlarged grain size will still persist. Now all of this is not merely something interesting, but important practically, for the reason that cold steel with big grains is steel in an inferior condition. Its tensile strength is less than normal. Further, we are to accept it as a fact that the bigger the grains the weaker the steel. As cooling off does not restore the normal, small size and high strength, it will be readily understood why oxy-acetylene welding and similar processes (inclusive of blacksmith welding) necessarily injure the steel. These processes must use high temperatures. It is not in the gas processes, merely, that the working flame is at a very high temperature; the work itself becomes highly heated, the temperature ranging from at or near the melting point to lower temperatures as one recedes from the beveled edges and away from the groove. In the groove, every particle of the new metal has been actually melted. Of course, there has been great enlargement of the grain size. The metal must be regarded as greatly inferior in strength to the same metal when in normal condition. This applies to the new metal in the groove, to the sides of the groove and to the metal back from the groove. Every spot where the temperature has risen above medium cherry red must be viewed as damaged in strength.

Protection Against Oxidation

This is not a question of the burnt metal. Burnt steel is afflicted with a different disease. When steel is actually burnt, the carbon has been consumed. It is the procedure of burning steel that is employed in cutting with a high pressure oxygen jet. By this process an oxy-acetylene or other heating jet is used to heat up the metal and the oxygen jet follows it very closely. The oxygen attacks the carbon and burns it. The welding operation with the oxy-acetylene flame may, however, be very well protected against oxidation. Considering the fact that oxidation might result from the oxygen passing through the torch, a proper adjustment of the flame to a neutral condition should cover the matter pretty fairly. Nevertheless, it is quite customary with many welders to use some very pure iron for the new metal. As this iron contains little or no carbon, it is but little subject to burning. In so far as oxidation from the atmosphere is concerned, the torch may generally be managed so as to utilize the large flame, which envelops the little working flame, as a protection. It is, from its very nature, a reducing flame and consequently adapted to this purpose.

Account of a Curative Procedure

In seeking to use the oxy-acetylene procedure in welding ships' plates, it is probable that a damage from oxidation could be provided against with a good deal of success by methods such as those just indicated. With this damage eliminated, however, we would still have the deterioration attendant upon the enlargement of the grain size. If the welding of ships' seams is to be a success, this deterioration must either be cured or offset. Piling up the new metal is a method of offsetting. I now proceed to give some account of a curative procedure.

If steel that has had its grains enlarged by overheating be cooled off to any point distinctly below *medium cherry red* (1,274 degrees F.) and then reheated, its grains will begin to break up and assume a smaller size at a point of temperature at or a trifle above medium cherry red. This is understood to be a pretty well ascertained scientific fact. If the steel contains about 0.85 or 0.90 percent of carbon and, consequently, no honeycomb either of pure iron or of

* Author of "Oxy-Acetylene Torch Practice."

cementite, then this method is understood to yield very perfect results. Indeed, down to 0.50 or 0.40 percent carbon steel, the method is to be regarded as quite good indeed. The stopping point on reheating, however, rises somewhat above medium cherry red. Below 0.40 percent carbon steel the method is less perfect, because a compromise has to be made between carrying the heat up a bit and having a resizing of the grains that is less than complete. There is, then, a known procedure for the restoration of the quality of the steel. This method, as indicated, requires that the work be reheated after the welding is completed.

A second curative procedure may be mentioned, though it is perhaps not so successful in the generality of cases. It has long been known that working steel under the blacksmith's hammer has a beneficial effect. It did not require the new developments in connection with the microscopic study of steel to reveal this broad fact. What has been uncovered of late years is a more precise knowledge of the proper "stopping points." Probably, steel that is going to be *thoroughly* worked may be subjected to working at pretty high temperatures, provided the "stopping point" is well chosen and the working is continuous from start to finish. The grain size will then be somewhat larger than that which corresponds to the stopping temperature. In short, the hammer or other device will break up the grains; but the prevailing temperature is also getting in its work.

Professor Bradley Stoughton Quoted

Oxy-acetylene welders have sought to get the benefit of working by using the hammer on the weld. Probably it does some good, provided the hammering is not continued until too cool a point is reached. Let me quote from Professor Bradley Stoughton.*

"Mechanical work will multiply the strength of steel from two to five times. In order to accomplish as much as this latter, however, it is necessary (1) to reduce the material to very small sizes, in order that the beneficial effect of the kneading action may extend throughout the mass, and (2) to finish the work cold, in order that the metal may have no opportunity to re-crystallize. The ductility also will be increased at first by working, but again decreases if the metal is worked cold. The increase in strength and ductility is due (1) to decreasing the size of the crystals and closing the grain of the steel; ..... (3) to increasing the cohesion and adhesion of the crystals. All these effects increase the specific gravity and hardness of the metal, and are more effective in these respects, as well as in increasing strength, if hot work is followed by cold work."

Restoration of Lost Strength

It is doubtful whether in the oxy-acetylene process full compliance can ever be given to the above requirement for a thorough kneading throughout the mass. Consider a longitudinal seam between two plates in a ship's side. Since the plates have been rolled in the process of manufacture, their normal strength presumably includes a decided advance on the strength of unworked steel. In fact, the high strength of the rolled plate was undoubtedly figured on in designing the ship. The process of autogenous welding materially decreases this strength because it undoes about everything that the rolling had previously accomplished. We seek to restore the lost strength by the use of the hammer. It would seem to be difficult, if not impossible, to reproduce with the hammer the condition which the rolling mill originally produced. Still, many difficult problems have been solved—this may be the next. Some mechanical device may be devised to work the metal in and along the seam to an extent equivalent to that accomplished with the rolling mill—some device which will secure penetration of its effects and will cover all regions involved in the high heat. Such an advance in the development of the oxy-acetylene process would not be anything very radical, since machine welding and cutting have both been done for quite a number of years. Wherever a machine can be used either for welding or cutting, better work can probably be done, as mechanical methods automatically secure evenness and regularity. Long straight seams, such as those on a ship's side, are particularly well suited to machine welding methods. It would seem, then, that a machine forger or kneader might very well handle this same class of work. Several years ago the present writer gave an account of European machines for the welding up of plate steel to form tubes. This process is very similar to the welding of ship plates. But I do not know of any machine which is especially adapted to work the steel after the welding operation.

One trouble with the hammer is the lack of penetration. "A blow creates in a metal practically nothing but compressive strains, which act chiefly in the vertical direction, and, by transmission, in the two horizontal directions. Because the pressure is relieved almost as soon as felt, the elasticity of the metal causes it to recover somewhat from the effect. This makes the effect of hammering superficial. Also the amount of yield to it is not great in proportion to its force, and therefore it takes more pressure to accomplish a result than would be the case if the application were slower. This makes hammering a slow process of reduction, but results in a better and more uniform working of the crystals on the surface at least, which is one of the chief reasons for the superiority of hammered over rolled material. Another reason, perhaps even more potent, is the exact control of the operation which can be exercised by the expert forger, especially his control over the temperature at which the work is finished, and over the varying forces of pressure applied at different stages and temperatures. On the other hand, the effect of forging extends only skin-deep from the upper and lower surfaces."*

Cold Drawing to Improve Strength

Perhaps a mechanical device could be produced which would exert an action superior to that of the hammer and more like that of the rolls in a rolling mill. It is quite probable, too, that the requirement mentioned in the preceding excerpt, which calls for cold working, can be more adequately and safely met by mechanical means. This is especially true if semi-skilled labor is employed. With a machine the regulation may be exact and uniform, insuring continuous movement of the steel particles, although small for any one moment. For example, cold drawing would be a very effective means of improving the strength of the material. Tremendous pressure, however, would have to be exerted in this process.

It will be easily gathered from the foregoing that the simple hammering indulged in by a lot of oxy-acetylene welders can be counted on but slightly. In the hands of a skilled welder who understands the thing at which he is aiming and the way to get it best with such a tool, the hammer is doubtless a good thing and the work will probably be the better for it. This is saying less, however, than that a full restoration can be thus accomplished or even approximated. In the hands of an ordinary oxy-

* Metallurgy of Iron and Steel," by Professor Bradley Stoughton, 1911, pp. 172 and 174.

acetylene welder, the hammer's usefulness would appear to be greatly limited.

After all is said and done, the re-heating method appears to be the better thing. It is all-penetrating, seeking out the regions adjacent to the weld and also regions inside the mass. It is not, or at least need not be, superficial in its action thus surpassing the hammer. Furthermore, heat is easily applied. In the first place, we have as a convenient source of heat the enveloping flame which surrounds the little white working flame. The temperature of this flame is not excessive—like that of the white flame—besides, it is safe, because of its character as a reducing agent. It has a great appetite for oxygen, so that it may be depended upon not only not to bring oxygen to the heated metal, but even to protect it from outside oxygen. Oxy-acetylene welders have been using this enveloping flame as a means of treating the weld, but that they have generally done so intelligently I am not prepared to vouch. The re-heating process, as has already been explained, gets its restorative results by heating up from a temperature point below *medium cherry red* (1,274 degrees F.). This is to be regarded as essential. It is not enough simply to wave the big enveloping flame over the newly welded work. Attention must be directed to starting the heat from a sufficiently low point—a cooling off must be accomplished first of all. It does not matter how cold the work is allowed to get. It may be a black heat or it may be stone cold. The point is to get it below 1,274 degrees. Naturally, in this re-heating procedure it is cheaper to heat up from a black heat than from a stone cold condition.

Action of the Enveloping Flame

But this re-heating does not have to be done with the big enveloping flame. This flame is a good one, especially since it has a reducing quality; but it is quite expensive, particularly in the present case. Sometimes there are uses for the enveloping flame which are advantageous and economical. This flame may at times be so managed as to provide a means of pre-heating without interfering with the simultaneous employment of the white working flame. When this can be done, the enveloping flame heats the work up through the early stages, thus relieving the white flame to this extent. To put this idea into use on steel plates in a ship's side, the torch might be controlled in a frame or bracket in such a way as to compel half of the enveloping flame to lie along the seam *ahead* of the white flame. The Edison Storage Battery Company has so used the oxy-acetylene torch in welding the vertical seam in the sheet steel containers which constitute part of a storage battery cell. The torch is held at a fixed angle by a holding device. The work is held in a clamp which carries it beneath the flame. The clamp is of such form as to divide the enveloping flame into two streamers, one lying along the seam ahead and one lying along the seam to the rear. Naturally, with the work fixed as in a ship's hull, it would be necessary to move the torch. The workman may do this or it may be done with a device adapted for shifting along the seam. This arrangement is calculated to quicken the welding operation, thus saving the time of the workman and reducing the expense for oxygen and acetylene. It is to be distinctly noted, however, that it does not provide for the restoration of the grain size of the steel.

To deal with the grain size, there must be an interruption. After the welding operation, the weld and adjacent work must cool, at least to, say, black heat before the re-heating begins. Consequently, the enveloping flame could not always be used simultaneously with the working flame, the latter doing the welding and the former doing the restorative work. There are, however, less expensive flames to use for re-heating—city gas or natural gas. That they shall act with great power is not so necessary as that they will not project products of combustion of a harmful character onto the metal. This point covered, almost any form of fuel will do that is reasonably manageable and capable of producing enough heat to bring the seam and adjacent regions up to temperatures ranging from full cherry red to, say, orange.

Objection to Refined Iron

It has been customary among oxy-acetylene welders working on steel to use some pure form of iron for the new metal to be put into the groove—Norwegian and Swedish iron and one or two American brands of refined iron. The idea seems to have been to prevent burning by supplying little or no carbon. The new metal is ordinarily in the form of a rod. Naturally, in moving this rod about it is liable to be exposed to the air. If it contained much carbon, the ordinary workman would probably be burning the hot end continually. Besides, the use of refined iron is at best only a partial remedy against carbonization, since the adjacent work may still be affected. Furthermore, it does not deal at all with the condition resulting from big grains.

A second objection to the use of refined iron for the restoration of the quality of the steel when re-heating concerns the matter of the normal strength of the material prior to any deterioration from any source. It is well known that iron is by no means as strong as steel. Only a comparatively few people know, however, that the tensile strength of steel is strictly proportional to its carbon content. This rule covers at least all steels below tool steels. Each small addition to the carbon percentage means a considerable addition to the strength.

H. H. Campbell gives, in effect, the following rule: Beginning with steel of a zero carbon content—40,000 pounds per square inch of cross-section is assumed as the ultimate tensile strength of basic or open-hearth metal—for each 0.01 percent added to the carbon content, 1,000 pounds is to be added to the initial valuation of the strength at 40,000 pounds.

It may be gathered from the foregoing that pure iron is hardly in the same class with steel. A weld made of pure iron will probably consist of material weaker than the adjacent steel plates, if the latter are of first quality, even if no deterioration of the iron occurred in the welding process.

Another Objection and Summary

I have also further objections to make to this custom. From information about iron and steel which has been developed during recent years, it is understood that the re-heating process is quite successful with steels containing between 0.50 and 0.90 percent of carbon, but less so with steels containing smaller percentages.

To sum up, the oxy-acetylene process can probably be employed with success in marine work, not only in connection with ordinary miscellaneous jobs, but with work of welding the joints in the hulls of steel ships. But—and note this "but"—if only the ordinary procedures are employed, the tensile strength of the material at and near the weld is to be reckoned as decidedly less than that of the plates. Restorative measures are possible, but they must be applied intelligently and adequately.

Selling a product below cost just to keep some other maker from getting the job is not business. Business is making money.

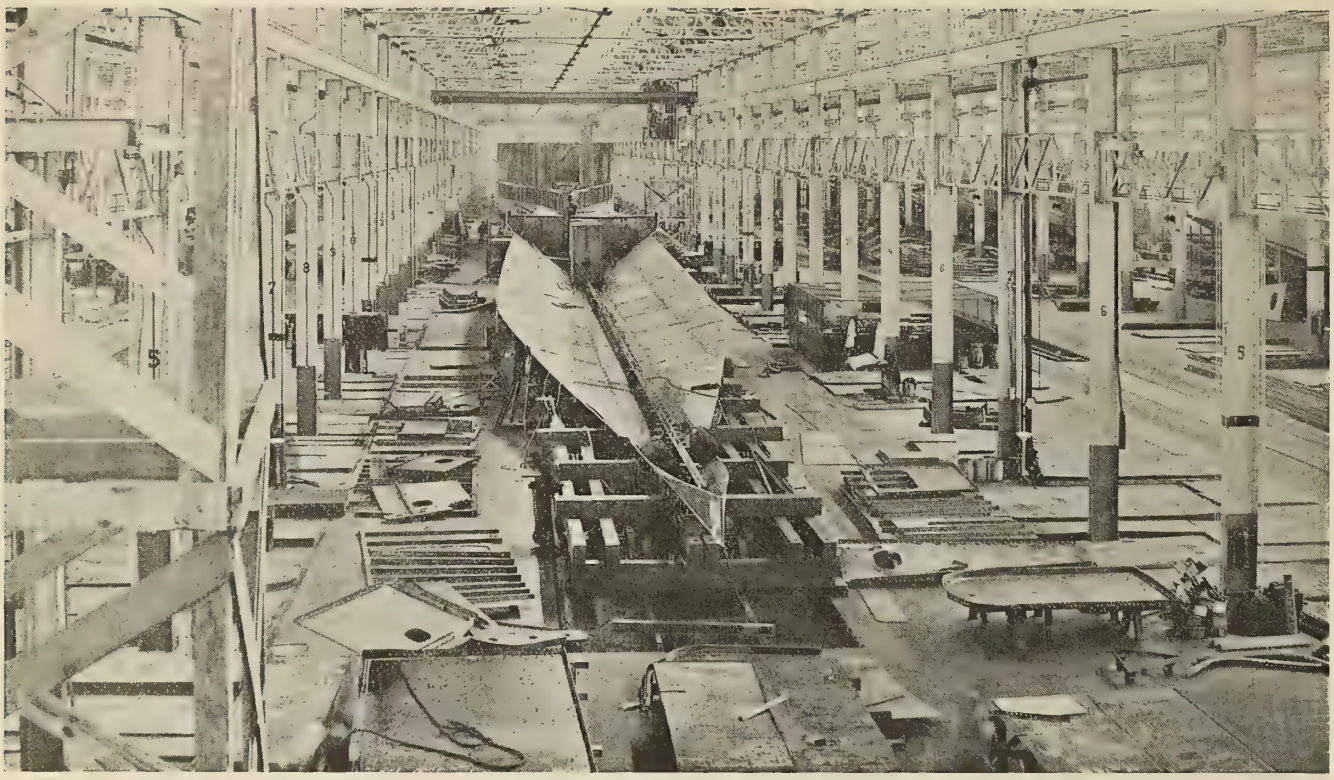


Fig. 1.—Station Where Keel, Bottom Plating and Bulkheads of Ford "Eagles" are Erected

Building the Ford Submarine-Chaser "Eagle"*

A Straight-Line Design—The Two Parts of the System—Hurried Development of the Process

IN its completed form, as it now exists, the "Eagle" manufacturing system comprises the following elements: (1) A factory design of ship, prepared in its entirety by the Navy Department, a design which has straight lines substituted for curves as far as possible, in longitudinal lines as well as in cross-section, and with the utmost simplicity and strength of structure; (2) multiple punching applied as extensively as possible; (3) preassembly or sub-assembly of parts that can be set in place as units; (4) erection of the ships in a long file moving forward to the material and to the workmen; (5) lateral short-distance movement of the hull materials from the storage piles to the ships; (6) step-by-step movement, the file advancing one station (the length of one hull) at fixed intervals (three to six days); (7) arrangement of the work in three parallel competitive working lines; (8) railway-truck mounting of the hulls during erection; (9) transfer of the completed hulls into the water by a hydraulic elevator; (10) installation of interior fittings, machinery and other parts in step-by-step progressive movement of the ships along the fitting-out dock, by a series of stations like those of the hull erection, and with short-distance lateral movement of the material.

The two parts of the system—hull assembly and fitting out—together constitute a straight-line progressive shipbuilding mechanism, but are physically separated by the launching platform at the center of the plant. A straight-line plant arrangement serves for carrying out the straight-line process.

It does not appear that any one of these elements is vital to the success of the fundamental task of building the ships rapidly. However, taken together they to-day constitute an integral mechanism—the "Eagle" production system—and they are so interrelated that each one is essential to the successful working of that mechanism. This mechanism grew together gradually during the evolution of the enterprise; its elements did not come into being as parts of one original conception.

The ship design itself underwent some change during the working out of the manufacturing procedure. Thus, originally the side frames were 6-inch heavy flanged channels, but when it was recognized that these might give trouble in beveling (required in the stern and bow sections) they were changed to flanged plates, following the design already adopted for the floors and brackets. Furthermore, the straking was changed so as to make as many as possible of the side and bottom plates parallel-sided and rectangular, to permit of the greatest possible extent of multiple punching. Some other changes of minor character were made in the design. The important development and change, however, were in the manufacturing system. Essential help in working out both the system and the design was obtained through the construction of a pattern ship in the Ford automobile works, even before the ship plant had begun to take shape.

Following Ford Assembling System

Taking the work to the material and men, the idea of the Ford automobile assembling system, was at first intended to be applied by a conveyor-like arrangement, the ship moving along continuously at very slow speed.

* Abstract through courtesy of *Engineering News-Record*.

Though the company was not experienced in shipbuilding, its successful development of automobile manufacture produced the conviction that the "Eagles" should be built under a roof and that the conveyor-assembly method was practicable and would result in great gain in time, cost and quality. In view of the novelty of its undertaking, the company did not call upon either naval architects or shipbuilders to plan the factory operations. Getting the new enterprise started was, under these circumstances, like building a machine of a wholly new kind and making it an operating success—which, incidentally, describes accurately the task of developing the turbine power plant with which the ship is equipped.

Time for leisurely and careful development of plans was lacking, under the urgent rush for earliest possible production. Prompt decisions and quick action were absolutely essential. The development, therefore, was a trying process to all concerned, and some steps were taken that conflicted with later decisions. For example, in order to get construction started, the buildings had to be designed before all phases of the manufacturing process were elaborated, and it was found afterward that somewhat different arrangements in this or that detail would have been better. That an efficient ship-producing machine was created under these conditions, and made ready for service in phenomenally short time, testifies to the value of the combination of able men concentrated on the work.

Continuous Movement Impracticable

In the development of the process, study based on shipbuilding experience early indicated that continuous movement of the file of ships was not practicable, as the individual operations in the hull assembly are necessarily slow and involve large quantities of material. Step-by-step movement took its place, the string of hulls to be shifted forward one ship's length at a time. Seven stations were decided upon; this number was not dictated by inherent requirements of the ship-assembly process, but rather by the anticipated rate of working and the space conditions at the site. The three separate assembly buildings were joined into one, with a material supply bay between and joining the assembly bays (line bays). Preassembly of parts then came to be recognized as an important agency of rapid working, and a length of about 200 feet was added at the incoming end of the assembly shop for doing this work. The progressive or step-by-step method was extended to the fitting out work, since this half of the manufacture involves as much labor as the hull construction and brings into action even a greater number of trades. Finally, after the shop was already in service, the order of assembly operations was fixed with regard to proper balance of time at the stations, as determined by actual experience in the shop. For fabricating the hull material, single punches were depended upon when the pattern ship was built. Later, machines were considered which would punch a group of holes at a time, the plate then to be shifted ahead by the length of a group. The example of bridge-shop practice prevailed, however, and multiple punching was adopted—using presses having a transverse gang of punches capable of being actuated simultaneously or in sets, and a rack for longitudinal spacing. The equipment plan of the punch shop was revised accordingly, after the building was under construction. Further development occurred later in balancing up the number of multiple punches and of single punches (for doing the work to which multiple punches were not adapted).

An important contributory factor in the success of the plant development lay in the large resources of the Ford Motor Company in machines and factory equipment. Thus the whole shop-crane installation of the River Rouge factory was brought together from Ford assembling plants all over the country, and the multiple punches which form the backbone of the fabricating end of the plant were fitted up from presses taken out of the sheet-metal department of the Highland Park automobile works.

General Description of Plant

Lying along the left bank of the widened and canalized River Rouge, some miles from Detroit, the plant extends

Fig. 2.—Table Upon Which Hulls Are Transported from Shops to Launching Platform

in a straight line downstream. Starting at the north end, its successive parts are the plate storage yard, the punch shop and, across a transverse road, the huge assembly shop which constitutes the main feature of the plant; just beyond this shop and a short distance to the right is the launching platform to which the hulls are moved by a transfer table. A few hundred feet downstream begins the concrete dock and ore storage space of the Ford blast-furnace plant. On this dock has been erected a long, narrow fitting-out shed, in two sections, each about 1,000 feet long, which hold the machinery and equipment for the finished hulls lying alongside the dock and moving forward in successive steps to receive different parts of the equipment. Supply warehouses nearby feed the fitting-out sheds.

Direct forward movement of material, in the least number of separate moves, characterizes the plant. From the storage yard, plates and shapes are moved into the punch shop partly by hand and partly by locomotive crane and cars. After the marking, punching and other fabrication, the material is loaded on short railway trucks moved by hand along one of four longitudinal tracks leading into and along the supply bays of the assembly shop. It goes directly to the place where it is to be assembled in the ship, and is unloaded and piled alongside that point. An exception is made in the case of material for pre-assembled parts, such as frames, deck sections, bulkheads and the like, which is unloaded at the head of the assembly shop and is bolted up and riveted there. The completed parts are then moved down the shop to the proper station by bridge cranes spanning the assembly bays.

Thus the material and supplies, having once reached the punch shop or the warehouses, undergo in general but a single move to a point directly adjacent to the place of assembly in the ship. From there a short cross-transfer only is required to put them in final position.

Largest Punch Shop in the World

Building up a working mechanism for carrying out this revolutionary process of ship construction was done with equal originality and disregard of precedent. Fully as impressive as the boldness of the designers, however, is the great size of the units of the plant. The punch shop in which material is fabricated ready for erection in the hulls is the largest shipyard punch shop in existence. The assembly shop contains twenty-one shipbuilding berths under one roof, and, in addition, a pre-assembly space. Indeed, the entire boat-building operations, stretching as they do in line a mile above the River Rouge, are covered by eighteen acres of buildings. The structures included are: A punch shop, an assembly shop, two fitting-out sheds, a transfer table, a launching bridge and several service buildings.

Primarily, the revolutionary shipbuilding methods are centered in the assembly shop. This shop represents the equivalent of twenty-one building berths, and in addition the finished material storage and the pre-assembly shop. It is the key feature of the River Rouge factory. All the hull erection work is carried on under its roof.

Description of Assembly Shop

The assembly shop is a steel frame structure 300 by 1,700 feet in plan, with clearance height of 36 feet 5 inches, except that the ship assembly bays have a clearance height of 50 feet 9 inches for 400 feet at the outgoing end. In spite of the great width of the building, excellent daylight is obtained throughout its area by ample glazing of sides and roof monitors.

Passing down the length of the building in three separate files, the hulls under construction occupy successively the seven stations indicated on the plan. Each file is separated from the next by a supply and material storage bay. All five bays are 51 feet wide. A narrower lean-to along each side supplements the supply bays. Bridge cranes span the assembly or working line bays. Each line bay is served by four 5-ton cranes, one of which is situated in the high part at the outgoing end. There are no bridge cranes in the supply bays, but instead several hand-trolley jib cranes are bracketed to the columns near the incoming end of the building.

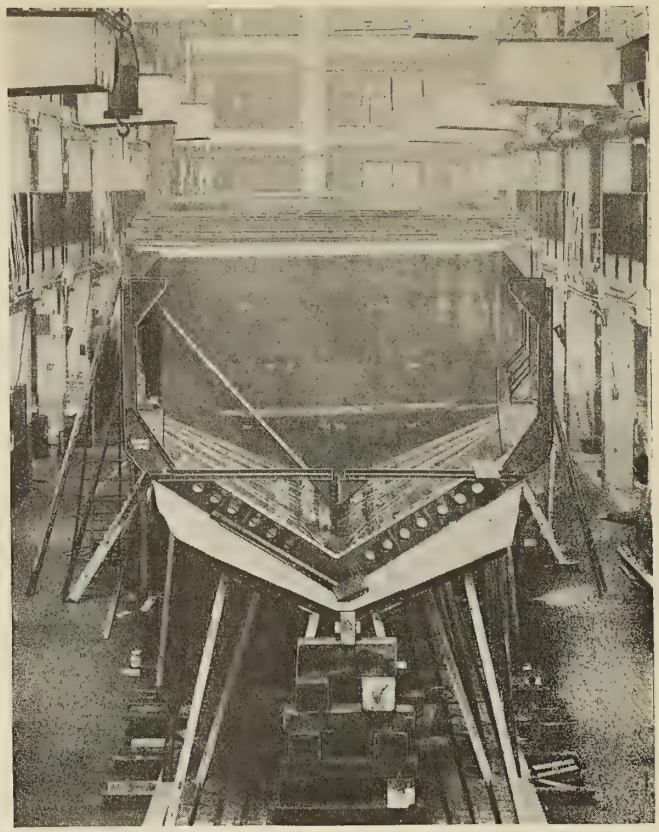


Fig. 3.—Pattern "Eagle" from Which Details Were Developed

By this arrangement, space is provided alongside each hull erection station for the material required at that station. Plates and other parts fabricated in the punch shop (at the right, a short distance from the incoming end of the assembly shop) move down the center of one of the supply bays on wheeled trucks running on a track the full length of the bay, and are unloaded directly at the station where required.

When the idea of erecting the hulls in a file of carriages moving along the railway track was conceived, the decision was also reached to use a standard gage track for this ship support because standard railway trucks could be used (with springs blocked). Though the wheelbase of 4 feet 8½ inches is narrow in comparison with the size of the ship, no trouble from lack of stability has been experienced. As the hulls grow, shoring is set against the bottom or the sides, either for temporary support of parts or to hold the ship securely in place. Aside from their wheel support, the trucks are secured against tipping by outrigger shoes attached to the truck bolsters and extending down to within ¼ inch of the rail of a track of 10-foot gage. This outer track is laid the full length of the working line bays, on the transfer table and on the launching platform.

The successive carriages of the assembly file are not connected as they would be under a continuous movement arrangement, but are moved individually when the file is

shifted ahead one station. The wedge keel blocks, a relatively late addition, provide for accurately level setting of the keel and any necessary readjustment. A hull carriage comprises eleven sections supported by twelve 4-wheeled trucks, but at stations 6 and 7 the two rear sections are taken out and the stern of the ship is supported by shoring from the track and platforms, to give room for placing the shaft bracket and boring the tail-shaft bearings. The weight of the hull at the time of launching is about 250 tons, of which 200 tons are structural material.

Organizing the Assembly Process

Organizing the assembly process was a matter of gradually learning by trial how much time the individual operations consume and how they can be allocated most advantageously to the different stations so as to suit the requirements of hull construction. A prominent factor in this development was the evolution of pre-assembly of parts. The large pre-assembly space at the incoming end of the building now has all its skids fully occupied with parts being bolted and riveted up. Riveting is done wholly by air hammers, although a horizontal gap riveter is provided in one of the bays.

Pre-assembly Key to Rapid Production

Pre-assembly of keel and keelson girder at station 1 constitutes a particularly interesting item of this preparatory work. It is done on horses immediately alongside the first station. When the file of hulls advances, and station 1 is vacated, a hull carriage is brought back from the launching platform (in separate truck sections) by the bridge cranes and is placed and assembled with its sills and bolsters. Then the finished keel is swung across to position on the keel blocks, ready for the setting of frames.

Until recently, frames, bulkheads, deck sections and tanks were the principal items pre-assembled. As it became increasingly clear that pre-assembly was the key to rapid station work, the subject was taken in hand more boldly. Now the complete stem section, about four frames long, and the stern for a length of about eight frames, are built complete on the skids and set in place as units. A great amount of handling, fitting and bolting is saved, which cuts down the building time and reduces the concentration of men. Furthermore, much riveting is transferred from the stations to the skids. About 15 percent of the rivets in the ship are driven in the pre-assembly.

One of the special devices developed for facilitating pre-assembly is a frame assembling gage. Here the separate floors, brackets and side members of a frame are set in proper position without any measuring or fitting, after the standards of the gage have been adjusted to the correct widths of the frame in question by a right-and-left screw in the base. Bolting up and riveting are then carried out quickly and with no uncertainty as to whether the correct shape of frame is obtained. This jig was designed by Superintendent Whiting of the assembly shop.

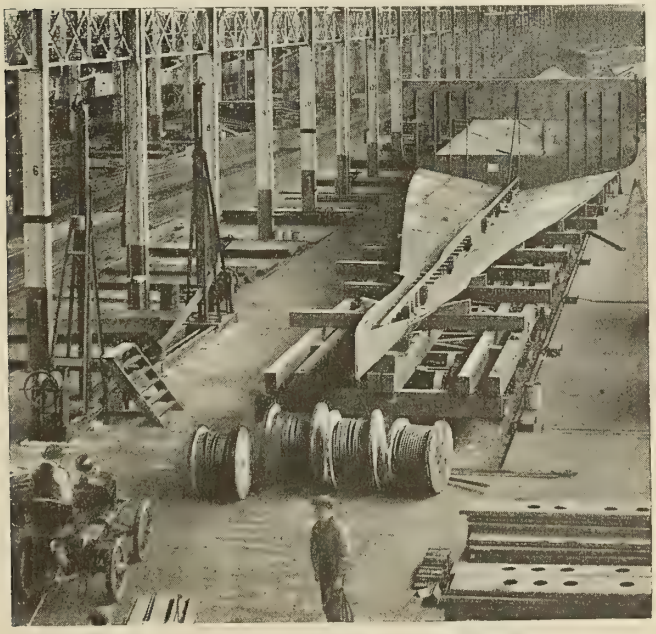


Fig. 4.—Special Gage to Facilitate Riveting

Organization of the Hull Assembly

Before the various operations involved in the hull erection could be scheduled as to order, and the items allocated to specific stations, many preliminary difficulties had to be overcome. With a new kind of ship and a new shipbuilding procedure the methods of doing some parts of the work had to be developed by actual trial in the shop. Every change in method—and sometimes detail changes in the construction of the ship—influenced other parts of the work as to best order and convenience. The time required for the several elementary operations could not be determined exactly at the start, and therefore an accurate balancing of the several allotments of labor and time to the stations was necessarily a matter of successive approximation.

One kind of difficulty is illustrated by the schedule for station 1. Originally the plan was to complete the entire main frame of the ship here, in order to produce a relatively stiff and robust hull structure before the first move. The early schedules were altered when experience on one or two hulls in the shop showed that this plan of complete frame erection consumed too much time for one station. Further, it was found that moving the carriage ahead on its track did not disturb the position of the parts perceptibly, even when the framing was not complete.

In the form finally adopted, the schedule of operations distributes the total work among the seven stations as nearly as possible in equal shares, except in so far as individual operations like that of boring the shaft bearings and subjecting the hull to hydrostatic test are locally governing factors to disturb the balance.

Side Keelsons and Stringers

At station 1, after the truck is made ready for the hull, the assembled keel is slid over from the assembly horses, the keel plate at the after end of this section is set, and then in successive order are placed the two bottom strakes, floors and bulkheads of the after end, the forward athwartship bulkhead, the assembled frames of the main portion of the ship's length, and the lower strake of the side plating. At station 2 the side keelsons and stringers are bolted up and the assembled boiler foundation and turbine foundation are placed; the bilge strake is set and a number of minor parts are added. Stanchions and platform deck beams are also set at this station.

Process of Riveting

Riveting begins at station 3 and continues throughout stations 4 and 5, being virtually completed before the ship goes to station 6. At station 3 the largest items of work are setting the unit assembly bow section and the corresponding stern section, finishing the main framing with stanchions and deck beams, setting the steering engine, and doing all the riveting below the platform deck.

(To be continued)

Naval Architects' Annual Meeting

Twenty-sixth General Meeting of the Society of Naval Architects and Marine Engineers—Abstracts of Papers Presented

THE twenty-sixth general meeting of the Society of Naval Architects and Marine Engineers opened in Witherspoon Hall, Walnut and Juniper streets, Philadelphia, Pa., on Thursday morning, November 14, with Lieutenant-Commander Stevenson Taylor, U. S. N., president of the Society, in the chair. The first business taken up was the reading and approval of the annual report of the secretary-treasurer. The report showed the membership of the Society on November 1, 1918, to be 967, as against 875 a year ago. Five hundred new members were unanimously elected. According to the treasurer's report, the total resources of the Society amount to $38,714.59 and the total liabilities $3,547.21, making the Society's present worth on October 31, 1918, $35,167.38 (£7,403).

The following deaths were recorded during the year: Honorary associate, Right Honorable Lord Brassey, K. C. B.; life member, Edwin A. Stevens; members, George W. Dickie, Charles R. Hanscom, Robert Logan, George W. Magee, Ignatius E. Thayer, William H. Varney, John D. Van Buren; associates, Harry B. Bloomsburg, Frank S. Masten, Thomas S. Matthewson, Jacob W. Miller.

Opening the convention, Commander Taylor announced the election by the council of Rear Admiral Washington L. Capps, U. S. N., as president, and other officers as follow:

Honorary vice-presidents—Rear Admiral David W. Taylor and W. M. McFarland, of New York.

Vice-presidents—J. W. Powell, vice-president of the Bethlehem Steel Corporation, South Bethlehem, Pa.; Commander H. I. Cone, U. S. N.; Lewis Nixon, New Brunswick, N. J.; Cecil H. Peabody, of Boston; H. D. Goulder; W. J. Baxter, naval constructor, U. S. N.; H. A. Magoun, vice-president, New York Shipbuilding Corporation, Camden, N. J.; C. P. Weatherbee.

Council—W. D. Forbes, New London, Conn.; Spencer Miller, South Orange, N. J.; C. F. Bailey, Newport News, Va.; Robert Haig, Chester, Pa.; associates, E. M. Bull, of New York, and C. M. Wales, of New York.

Executive Committee—Commander Stevenson Taylor, Andrew Duncan, W. M. McFarland, F. L. DuBosque, and J. W. Powell.

The president of the Society then read his annual address, from which the following extracts are taken:

Abstract of President Taylor's Address

After reviewing the changes that twenty-five years, a quarter of a century—a generation—have brought to the Society; and then entering upon a review of American shipyard production and methods to date, President Taylor turns feelingly to the future, with an appeal on behalf of the merchant marine.

America's one great problem with the realization of peace, he points out, is, in effect, What was to be done with the merchant marine? Shall we as a nation supinely, as in the past, permit other nations to carry our entire commerce overseas? It is to the merchant marine that we must particularly attend, and now that the end of the war has come, the problems following the destruction and disorganization caused by the war demand the attention of our best ability and judgment. It is the one great problem for us to consider. Certainly it is incredible that any administration in the United States Government shall sacrifice the great funds and efforts individually and collectively that have been expended in the last two years to build up facilities, educate men, and women, too, in order that we may have and operate ships of our own. If there are laws upon our statute books that prevent our reasonable operation of ships, they must be amended.

And yet we may look to the future with optimism. We must neither think nor say that it cannot be done. It can be done, as we have so ably proven during the past year, he maintains, and then concludes: "We have performed gigantic tasks more rapidly in all the circumstances than could any other nation in the world. We shall build ships, we shall secure and train officers and sailors, and we shall establish and keep forever a merchant marine on the seas of the world; for the sea was in our fathers' blood, the ocean is our birthright."

Delamater Iron Works—Cradle of the Modern Navy

BY H. F. J. PORTER

ABSTRACT

In the late thirties of the last century, the author points out, a group of machinists, foundry men and expert mechanics who lived in what was then Greenwich Village, a suburb of old New York, joined forces and founded the Phœnix Foundry. Cunningham, Hall DeLamater (the elder), Hogg, Rider and Warden are the names associated with the venture. To this group of men was introduced John Ericsson, then a young, well-born Swedish engineer, who had developed plans for a steam frigate in which the United States Government was interested. Especially close was the intimacy of Ericsson and young DeLamater, then about twenty years of age, and rarely in later years did either take a step in the nature of a business venture without consulting the other.

In 1842, Ericsson was commissioned to do the engineering work of designing the engines and hull of the iron frigate *Princeton*. Ericsson at once placed the order for the engines and the propellers with the Phœnix Foundry, and the hull was constructed at the navy yard in Philadelphia. This was the first iron steamboat built in this country, and with its propeller wheels and engines wholly below the water line, presented a design which was at once adapted by this and all other countries for naval vessels of the future. In this beginning, which was later followed by further advances just as radical, these works should easily lay claim to being "the cradle of the modern navy."

In 1842 the fortunes of the Phœnix Foundry were continued under the name of Hogg & DeLamater, later known as the Hogg & DeLamater Iron Works. In 1858, the shop became known as The DeLamater Iron Works.

When the Civil War broke out, these large and well-equipped shops possessed special facilities for war work, and Mr. DeLamater promptly offered them to the Government for such work as might be needed. Knowing Ericsson's mental equipment in ordnance engineering science, Mr. DeLamater frequently consulted with him about the work they would be able to do for the Government. In the dire extremity of the country, Ericsson's plan for the *Monitor* was rushed to completion. The keel of the *Moni-*

tor was laid by Thomas F. Rowland at the Continental Iron Works, Greenpoint, Long Island, October 25. Steam was applied to the engines at the DeLamater Iron Works December 30. The men who actually operated the engines and boilers of the *Monitor* in the battle were from the DeLamater Iron Works.

Immediately, the works received orders to build six vessels of the same type, but of various sizes, some of them much larger than the *Monitor*. The war vessel was changed in one day. The Monitor type became the war vessel of the world. The hulls of these boats were constructed at the Brooklyn Navy Yard and private shipyards; the engines, propellers and other machinery were provided by the DeLamater Iron Works.

From this time on the works were known as the germinating place for new ideas—"the works became a veritable nursery in which inventors had their ideas developed." In 1869 the works built thirty gunboats for Spain as protection against Cuba. In the same year they built the *City of Merida*. In 1874 the *Dictator*, which had originally been built in the DeLamater Iron Works, a boat of the Monitor type—returned for speedy repairs to combat the Cuban scare. Captain Ericsson, who had been at work on harbor defense at this time, developed the *Destroyer*, which carried a submarine gun and discharged a compressed air projectile 30 feet long, loaded with 350 pounds of explosive. The DeLamater works built and launched it very successfully. Later, John Holland, a Roman Catholic priest, had his first submarine torpedo boat built there.

The development of this large works ceased with Mr. DeLamater's death in 1889. It was in the minds of most men a great calamity that Mr. DeLamater should have died when he did and that the works, which he built up and maintained with so much effort and at times with severe struggle, and which always took such a prominent part in the history of the nation, should have ended its career simultaneously.

Revival of Wooden Shipbuilding as a War Industry

BY CARLOS DE ZAFRA, M. E.

ABSTRACT

This is an interesting paper, pointing out that the supremacy of nations has been ever proportional to their command of the seas. Greek history, Egyptian history, Roman and Spanish history, the author goes on, are each most exciting during their respective sea power periods. Little difference did it make were the propelling force man power, as exemplified in the 40- and 60-oared galleys of medieval days, or sail or steam, as of to-day. Dealing with the present era, steel seems to have been introduced as a shipbuilding material about 1870, but there is no denying that the wooden vessel had given excellent service, and in the emergency in which we recently found ourselves, and notwithstanding the tremendous steel output for shipbuilding purposes, the wooden ship, which gradually had become obsolete, was again brought into its own.

In connection with the present shipbuilding activities, the author continues, there has been considerable speculation as to what will be the amount of tonnage produced by the United States during the year 1918. A recent estimate places this amount at 4,000,000 tons deadweight capacity—even 6,000,000 tons have been mentioned in an offhand way. Stupendous events and undertakings are under way, and the expectations of the allied governments are such as demand tremendous results from us.

The sudden revival of wooden shipbuilding as a war industry necessitated a revival of old shipyards, their enlargement and modernization. It meant the return to shipbuilding of many who, through its decadence as an industry, had sought a livelihood in other directions. It caused the construction of new shipyards from new materials and under the guidance of new minds—and, strange as it may seem at first, some of the most successful of the new enterprises have been under the jurisdiction of the "landlubber," the constructor and the civil engineer.

To-day's problems have introduced some new details of construction. On the Pacific coast long timber is available, keel sticks being from 80 to 100 feet, and in a few instances, I am told, as long as 150 feet between scarphs, while on the Atlantic coast a 50-foot length would be considered a good specimen. On both coasts, however, steel has been introduced for keelsons and for brackets or braces to supplant the ever-decreasing supply of ships' knees.

The use of iron strapping on wooden vessels necessitates rabbeting the frames so that the frame and strapping surfaces will present a smooth face on which to lay the planking. To expedite this work, a portable pneumatic rabbeting tool has recently been developed and used with excellent results.

Painting by the old hand-and-brush method was laborious, time-consuming and ever wasteful. The use of compressed air has solved these difficulties to a great degree.

On the west coast we prided ourselves when a new keel was laid in twenty minutes after the launching. Later we beat it at sixteen minutes, later at eleven minutes, and finally got it down to one minute—a world's record. In the old days many weeks would elapse before a new set of keel blocks was ready and the new sticks were scarphed and ready for assembling and fastening. Now, thanks to the introduction of quantity production and fabrication methods to wooden ship production, we can use the same keel blocks without disturbing them at launching, and by having the new keel all in readiness under the bilges it can be hauled to place on the vacated keel blocks as rapidly as the sister ship glides to her maiden plunge.

Application of Buoyancy Boxes to the Steamship "Lucia" for the United States Shipping Board

BY W. T. DONNELLY

ABSTRACT

The unprecedented sinking of vessels by submarines in the early part of 1917 directed universal attention to the possibility of protecting ships against the attacks of the submarine. The result was a tremendous influx of ideas—scientific, practical and impractical—to all the departments in Washington, and it soon became apparent that some organization must be gotten together to handle this mass of material and meet by counter endeavor, if possible, the menace of the submarine. This resulted in the creation, jointly, by the Naval Advisory Board and the United States Shipping Board, of the Ship Protection Committee. The preliminary work of the committee consisted of classifying and considering several thousand suggestions dealing with many real, and more imaginary, methods of overcoming the submarine.

The method of rendering a ship safe against sinking by internal buoyancy boxes was the outcome of the writer's experience in the construction of floating dry docks, and this experience has been embodied in a United States patent, dated April 17, 1917.

The idea first took shape before the committee in a copy of this patent submitted from the Patent Office by a clerk of that department.

The writer, on behalf of the committee, prepared preliminary plans and calculations and investigated the vessels available. This resulted in the selection of the former

Austrian steamship *Lucia* of the following general dimensions and tonnage: Length, 418 feet; beam, 54 feet; depth, 37 feet; gross register, 6,744 tons; net register, 4,386 tons; coal bunker capacity, 620 tons; water ballast, 1,583 tons; deadweight capacity all told, 9,600 tons; summer draft, 28 feet 11½ inches.

The *Lucia* was a modern steel freighter, built in Trieste, Austria, in 1912 and equipped with English machinery.

From the plan as outlined by the figures and drawings it appeared simple, but the carrying of it out for the first time under war conditions was found to be anything but a simple matter. The only material available immediately for creating the buoyancy boxes was ordinary lumber and galvanized iron, and the quantity of sheet metal required was rather a surprise to local markets.

It was soon found that ordinary methods of construction would not do, and careful experiments were necessary to develop the details of construction for the boxes as set forward in the plan.

After the type of box and entire construction for withstanding pressure had been developed, many difficulties were met with before absolutely watertight results could be obtained, and these results were finally maintained only by testing every box by air pressure and floated in a tank before placing it in the vessel. Approximately 12,000 boxes, divided equally between buoyancy boxes for ship, or cargo, were required.

From a strictly engineering point of view, to question the possibility of rendering a vessel unsinkable under ordinary conditions by such a method is beyond dispute. It is simply a question of the quantity and strength of the buoyancy boxes used. To question the carrying capacity of the ship when so fitted is to question the simplest form of mathematical statement which can be made.

Finally, in the general question of whether ships shall be made unsinkable at sea or not, the time required to so construct a ship will have no bearing whatever upon the problem. The writer is free to admit that military reasons may properly control any action, commercial or otherwise, during a time of war, but at the same time begs to state that only engineering and economic reasons will finally control the question of rendering ships and cargoes safe against loss at sea.

Discussion

After presenting his paper, Captain Donnelly read from another paper which he had prepared since the sinking of the steamship *Lucia*. This second paper set forth clearly that the sinking of the vessel was due to a shifting of her cargo, consisting of heavy trucks. These, it appeared, had pounded their way through the upper decks and into the hold, where the impact had set up stresses which eventually proved disastrous to the ship. Discussion was submitted from the auditorium to the effect that it probably would have been better if the government had turned its attention to methods of destruction of submarines absolutely, rather than to the subject at all of methods of saving torpedoed boats. Captain Donnelly rejoined that the saving of life and cargo was fully as necessary as was the destruction of that which made necessary the saving of life and cargo—submarines. There was nothing more said.

Notes on Progress in Turbine Ship Propulsion

BY FRANCIS HODGKINSON

Abstract

This paper sets forth, among other things, that it is common practice on shipboard to provide a closed or tubular heater to which is led the exhaust steam from the auxiliary machinery, which latter exhausts at a pressure between 5 and 10 pounds gage. The exhaust system is provided with a connection to let any proportion of this steam to the condenser. Sometimes again there is a hand valve, permitting any surplus of this steam to be taken to a low pressure stage of the turbine, all of which calls for hand manipulation where the conditions are sometimes quite variable, owing to more or less intermittent operation of the feed pump. Sometimes the connection to the condenser is provided with a spring-loaded valve, so that when the exhaust pressure reaches a predetermined pressure, higher than that within the condenser, steam may pass to the condenser. The construction of the valves usually employed is such that the higher the pressure in the condenser, the higher is the pressure at which the steam will pass to the condenser, which is, of course, undesirable. A system which will automatically maintain a predetermined temperature in the feed heater at all times, bleeding the main turbine for this purpose, at high powers if necessary, and at the same time automatically permit any surplus steam not condensed in the feed water heater to do useful work in the turbine, is much to be desired.

Steam Pressures

The attention of central station engineers at the present time is being directed to employing higher boiler pressures, viz., pressures as high as 600 pounds. To-day 200 pounds pressure and 200 degrees Fahrenheit superheat are regarded as a more or less everyday operating condition for large plants. Steam generated at 600 pounds pressure, having exactly the same heat content as that contained in 200 pounds pressure and 200 degrees Fahrenheit superheat will have a superheat of approximately 128 degrees Fahrenheit. This, expanded to 29 inches of vacuum, is theoretically capable of giving 13 percent more energy than when generated at 200 pounds and expanded to the same vacuum. Doubtless, when operating under the high pressure conditions, the turbine will be of lower efficiency. The high pressure element will be less efficient on account of the great density and the small volume of the steam, and, on the other hand, the low pressure elements will be less efficient because of the great amount of water precipitated by the steam expansion from the high pressure, introducing a brake in the turbine. However, it is reasonable to suppose that the turbine will avail itself of at least 50 percent of this 13 percent possibility, producing a net saving of 6 or 7 percent.

Governing Arrangements

With the old reciprocating engines, racing in heavy weather was always to be reckoned with. While governing arrangements were sometimes furnished by the builder, they usually passed most of their existence in a storeroom locker. To-day the reciprocator may accelerate rapidly; it may generally run at proportionately higher relative speeds than the turbine, without injury.

With the direct connected turbine, governors used always to be fitted, but were subsequently found to be of no particular value because the small diameter high-speed propellers, always being given the maximum submergence, seldom came out of water with the vessel pitching. With the geared turbine the propeller dimensions revert to that of the reciprocating engine, and while, because of its inertia, the turbine and gear may accelerate less rapidly than the reciprocator, very material increased speeds would be destructive. Therefore, a very dependable regulating mechanism is desirable which must at least have some semblance of being able to regulate and must not be

a mere stop governor which on the speed reaching a predetermined limit will slam shut an automatic valve.

There is much difference of opinion concerning the relative merits of gear and electric motor drive. Discussion of this important matter is refrained from here in view of certain battleship installations now being carried out. Unquestionably these installations will be entirely successful and will fulfill all expectations, but whether the added complication, increased cost and weight of machinery, together with increased steam consumption per propeller horsepower, are warranted, can be shown only by the development of the future.

Discussion

It was pointed out by Professor H. C. Sadler that in all probability it would be advisable to be a little careful about adopting geared turbines for the merchant marine. Ignorance or carelessness on the part of operators, while undoubtedly accounting for some of the troubles, yet did not wholly cover certain of the difficulties which were making themselves manifest in this type of propulsion.

Notes on Launching

BY WILLIAM GATEWOOD

Abstract

In connection with the launching of large and heavy vessels, for which launching calculations are made, two conditions of the operation usually receive especial attention, the author explains. One is the pivoting pressure, or reaction on the ways when the stern begins to lift, and the other is the minimum moment against tipping.

After stating that the calculations, as usually made, are well known to naval architects and may be found described in the transactions of this and kindred societies and in text-books on naval architecture, the author proceeds with a bit of history.

Suitable provision for taking the pivoting pressure on the fore poppets was early recognized as essential, he begins. It was recognized, also, that some means of distributing this pressure is necessary, as theoretically the pressure is concentrated on the extreme forward end of the sliding ways. In the early days, the fore poppets were built of timbers on end, but it was soon noticed that this was not a good practice, as the compression of end grain wood is quite small compared with the compression when the grain is flat. By building up the fore poppets with the wood laid flat, an appreciable amount of compression occurs at the forward end when the vessel pivots, and the under surface of the sliding way is enabled to remain in contact with the upper surface of the groundway over an appreciable length, thus distributing the pressure between the two pairs of surfaces.

As the launching weight of vessels increased and the pivoting pressures changed from a few hundred tons to more than two thousand tons, some more definite means of distributing this pressure became necessary. The introduction in the fore poppets of a considerable depth of soft wood with grain flat seems to have served the purpose in some cases, notably in the launching of the *Lusitania* and *Mauretania*. A special rotating device or rocker formed as a segment of a trunnion has been used successfully, as described in volume 22 of the Transactions of this Society. Curving or cambering the forward end of the fore poppet cribbing to introduce a clearance for the adjustment of the bearing surfaces has been used, as noted in the discussion on the paper above referred to. Strips of soft wood especially proportioned to crush under pressure were used in the fore poppets of certain vessels launched on the Pacific coast, as described in volume 12 of the Transactions of this Society. The height and general construction of the fore poppet will determine what depth of cruising strips can be fitted, and the maximum crushing in inches which can be counted on will regulate the portion of the overlap of the ways which will be in contact.

The minimum moment against tipping is primarily the measure of safety against the lifting of the fore poppets from the ways and the bodily tipping of the vessel backwards as the center of gravity of the vessel passes the end of the groundways. Many of the smaller vessels have "tipped" in launching because it was considered too expensive to extend the ways a suitable distance under water. Usually, no damage has resulted from this practice, as the pressures have been comparatively small and the ways were so supported as to "give" appreciably during the tipping. The settling of the ways, compression of the packing and deformation of the bottom of the vessel all tend to distribute way-end pressure, but it is manifestly unlikely, if not impossible, that the distribution of pressure can be as indicated by the trapezoidal formula.

Although the cruising strips do not exert nearly as much pressure in returning to their original thickness as they do in being crushed, the author concludes, the recovery is appreciable, and there will be a considerable pressure exerted between the bottom of the vessel and the sliding way outboard of the end of the groundway. This pressure may be sufficient to break the sliding way if there is an appreciable crushing of the strips, as the sliding way has considerable rigidity. The excessive bending moment on the sliding way may be relieved by cambering the last few feet of the groundway.

Side-Launching of Ships on the Great Lakes

BY EDWARD HOPKINS

With the advent of iron and steel shipbuilding on the Great Lakes, together with the fact that the location of most of the yards was not advantageous for end launching, though occasionally small vessels are launched endwise, side-launching was adopted and has continued to the present day, and is receiving consideration and has been adopted in some new yards that have been established outside of the lake district.

The preparation of the ground for building ships that are to be side-launched is much the same as for ships built for end-launching, with the exception that the ship is on a level keel when building. This is considered by lake shipbuilders as a great advantage, not only for general accessibility and the saving of scaffolding and blocking, but everything is plumb from the keel, which being level no rake has to be considered.

As most of the ships are built on permanent berths, and as these berths run from 80 to 100 feet in width, this, with the inclination of the ways, usually from 1¼ inches to 1½ inches to the foot, assures a height of keel blocking from 4 to 5 feet, which gives good working room under the ship's bottom.

There are no extensive launching calculations required for side-launching. Illustrations may be had revealing how uniformly the ship is borne at all periods, and the time from the releasing of the vessel until afloat is so short that no undue stress is placed upon the structure. Of course, the necessary calculations for stability after launching are determined, no matter what method is adopted.

Side-launching is especially adapted for repair yards where the graving dry docks are used for launching slips, as may be seen in a plan of the Toledo yards.

The methods used and arrangement of the building berths for side-launchings are, for all practical purposes,

the same in all Lake shipyards. The methods and arrangements used by the Toledo Shipbuilding Company are aptly illustrative of this description. The cross-section of the building berth, however, which Mr. Hopkins uses to clearly illustrate the special points of his paper, shows reinforced concrete groundways and shoring stringers. The other berths used are of the usual type, with piling and timber shoring stringers, and supports for the groundways, which are usually of oak or fir. They are placed between the keel blocks about 10-foot centers, extending from the inside bilge to the water's edge.

On the concrete groundways noted above, the lower half is covered with oak flitch 6 inches thick, forming the groundway. The upper half is of the usual size timber launching way and is hinged about the center of the berth, so that it can be dropped down until needed for launching, giving free access to the space below the ship's bottom.

The arrangement of these ways and launching tables were made for a ship of 3,500 tons deadweight, of the type now building by this company for the Emergency Fleet Corporation. The dimensions of the ship are as follows: Length overall, 261 feet; beam, 43 feet 6 inches; depth, 21 feet. The length and beam are the maximum that can go through the canals from the Lakes to the sea.

While the time required for side-launching is very short, the launch is much more spectacular than an end-launch, there being usually a drop of from one to three feet off the end of the ways.

In a recent launching in one of the Lake yards, the drop from the end of the ways to the water was only one inch less than 14 feet. No damage resulted to the hull structure.

About three weeks before the date set for a launch, the groundways are placed, and a week later the packing is placed under the ship. The triggers and daggers, two sets at each end for a ship of this size, are put in position a week before the launch, and three days before launching two patent key-blocks are placed under the keel at each end, these being the last keel blocks left under the vessel. They assist in relieving the stress on the triggers until the last moment.

The triggers are levers, two at each end, pivoted against chocks secured to the groundways. Daggers or shores extend from a point on the trigger just clear of the chocks to the ship. At the other end of the triggers, bights of rope are turned, extending back and fastened to piles or other secure anchorage. These ropes are cut with axes by men when signaled. The triggers and daggers drop away and the ship is free to move.

The signal device used consists of three vertical semaphores, pivoted to a platform located at each end of the ship, on the lower or water side of the building berth and clear of the ship's way, in sight of each other and also in sight of the men who are to cut the ropes, holding the triggers.

About half an hour before launching, the wedging up or rallying is started; first on the upper or land side until the shores drop out, then on the lower side until the shores drop out; then again on the lower side, rolling the ship so that the keel blocks can be easily removed. The patent or key-blocks, as before stated, are removed last.

The first of the semaphore signals is dropped when all the shore and keel blocks are out, the second when the key-blocks are out. Usually, at this period of the operations, the ship has moved a little, which is followed up by the jack shores fitted at each end of the ship. If she has not moved, the jacks are worked until she moves. The ship is now ready to let go, and the last signal is dropped to cut the ropes, which is done simultaneously at both ends.

The data from launch of the 3,500 deadweight ton ship are as follows: Declivity of ways, 1½ inches per foot; launching weight, 1,170 tons; area of sliding ways, 289.5 square feet; tons, weight per square foot, 4 (will go as high as 9 to 11 on large ships); time from start to leaving ways, 6.5 seconds; velocity in feet per second, 9.08 feet.

Discussion

This paper was very well received. Among other advantageous features which side-launching possessed, Captain W. T. Donnelly emphasized the one of economy of structure. Launching-ways of this type were built at little cost as compared with the end type of ways, while the danger of faulty delivery of the vessel was proving negligible. So long as the hull was practically thrown into the water, as against a long and slow angle of glide, there would be no troubles encountered. Captain Donnelly strongly recommended side launchings.

Structural Steel Standardized Cargo Vessels

BY HENRY R. SUTPHEN

This paper is printed in full on page 695.

FRIDAY SESSION

On Vibrations of Beams of Variable Cross Section

BY N. W. AKIMOFF, ESQ.

Abstract

As a general rule, the author states, a vibration taken at random is a mixture of the fundamental with several harmonics. Any compound vibration can be decomposed by analysis, or by means of special instruments, into its primary elements (so-called normal modes), fundamental and overtones. Now, if there is any disturbing periodic force (such as an unbalanced engine), and if its period happens to be the same (or nearly so) as that of one of the normal modes of the free vibration, we have synchronism, where the effect is generally quite out of proportion to the magnitude of the disturbing force. For instance, the vibration due to a reciprocating engine is compounded of the fundamental, the first harmonic (of double frequency) and of the second harmonic (of three times the frequency of the fundamental); higher harmonics, as a rule, are not felt. Now, if any one of these frequencies is the same as any of the natural frequencies of the structure, its effect will be felt in a marked degree.

The reader, if unfamiliar with elastic vibrations in general, is advised to carefully study the fourteenth chapter of Morley's excellent book, "Strength of Materials," where many useful formulae will be found.

Experiments on Simplified Ship Forms

BY PROFESSOR H. C. SADLER AND T. YAMAMOTO

Abstract

The question of the simplification of ship forms is one that has received a good deal of attention during the past year. In their anxiety to produce a simple form from a structural standpoint, a good many designers not familiar with ships have ignored entirely the question of economical propulsion. During the past year some experiments upon "straight frame" forms were conducted in the tank at the University of Michigan, and the results are thought to be of sufficient interest to place the same on record. The main object of the experiments was to determine what difference in resistance existed between an ordinary shipshape form and one in which the curved form of the frames was replaced by straight lines. No particular attempt was made to develop the best possible form, but the main features of the two types were kept constant.

The diagonal line representing the corner was in all cases made a straight line, with the view that if the bilge corner were cut off this would facilitate construction. The results of the tests show that the effect of retaining the corner volume at the bilge is to increase the resistance about 3 to 4 percent, or approximately the same as that due to the added surface. Compared with the shipshape form, there is practically no difference in resistance between this and the simplified form with the corner cut off.

Although time did not permit of carrying out a complete set of rolling experiments, some of the models were tried and it was found that the effect of the sharp corner upon the reduction of rolls was most marked, and that even with the corner removed these models came to rest quicker than the shipshape form.

The general conclusions that may be drawn are, the author states, in closing, as follows:

1. Vessels of the straight frame type can be designed which will have about the same resistance as a shipshape form.

2. If the diagonal line of the corner be given the wrong slope, this will increase the resistance due to the lack of conformity with the proper stream line flow.

3. The effect of maintaining the square corner is to increase the bare hull resistance, but as vessels of this form would not need bilge keels the net result from a horsepower standpoint would be about the same as for a shipshape form.

4. Probably the best results from a resistance standpoint would be obtained by using diagonal line which is of a curved form in the body plan.

Variations of Shaft Horsepower, Propeller Revolutions and Propulsive Coefficient with Longitudinal Positions of the Parallel Middle Body in a Single-Screw Cargo Ship

BY NAVAL CONSTRUCTOR WILLIAM MC ENTEE, U. S. N.

This paper will be published in the January issue.

Recent Developments in Shipyard Plants

BY NAVAL CONSTRUCTOR S. M. HENRY, U. S. N.

ABSTRACT

In this paper the author sets forth the nature of the difficulties overcome in bringing shipyards to a point of production commensurate with the demands imposed by the war and embraces all phases, such as building and repairing slips, crane service, structural shop, fitting-out crane, turret shop, forge shop, foundry and machine shop. He thanks the present demand for ships for the progress that has been found possible in the development of the plants. With a continued demand for more and larger ships, it is to be expected that the growth of the plants, which has been begun, will be rounded out so that each department will in its own line be able to compare favorably with the best shops doing a similar character of work in other industries.

Present Status of the Concrete Ship

BY R. J. WIG

ABSTRACT

Establishing the fact that there is much interest throughout the world in the development of the concrete ship, the author declares that the use of reinforced concrete for ship construction has been suggested by the structural engineer and not by the naval architect. Like all innovations, the author continues, its development has been observed by some with much skepticism. The structural engineer has worked under a great handicap in not knowing the premises of ship design, and during these very busy days of the past two years it has been difficult to obtain the assistance of naval architects who could join the structural engineer in adopting this new material to ship structures.

Unfortunately, the structural design of ships in general has not been developed on theoretical grounds, but rather from empirical standards and experience. Reinforced concrete is such a radically different material from steel and has such dissimilar physical properties that it has been necessary to devote much time to theoretical analysis of the ship structures which is not undertaken at all in steel ship design.

The concrete ship is truly a product of necessity. We have been working on the concrete ship comparatively a very short time and therefore we do not expect the present ships to be the ultimate concrete ship; they must be judged as pioneers, and imperfections are to be expected. Since the concrete ship of large size (3,000 tons and over) is being developed almost wholly in the United States by the Emergency Fleet Corporation, a discussion of the present status of the concrete ship will be confined largely to a discussion of this work.

Torsional stresses are produced when the ship passes over the waves making an acute angle with the waves. In order to find what increase of stresses can be expected due to this effect, an analysis was made of the torsional moments and the stresses produced by them. To find approximately the wave condition giving the maximum effect, a rectangular waterline section was first assumed, width one-eighth of the length. The usual assumption was made that the hydrostatic water pressure varies directly with the depth under the wave surface. For the sake of simplicity, a sine wave was assumed instead of a trochoid, correction for the difference being made afterwards. As usual, the wave height was taken one-twentieth the length. The maximum torsion midship was then found to occur when the wave crest makes an angle of 19 degrees with the ship, when the line of the wave crest passes through the center of the ship and when the length of the wave is 0.475 times the length of the rectangular waterline section.

In addition to the analytical studies, it has been necessary to obtain data on the physical properties of structures of unique design and concrete mixtures which had seldom before been used in structural work. These structural investigations are made under the direction of W. A. Slater at the Bureau of Standards' laboratories at Washington and Pittsburgh, the laboratory of Lehigh University at Bethlehem, Pa., and the Office of Public Roads, Arlington, Va.

The investigations are made to establish safe working stresses and standards of design. Tests already made demonstrate the safety of the designs first made and indicate how weights may be further reduced without sacrificing strength.

Our general knowledge of reinforced concrete as compared with steel structures makes the success of its further adoption for ship construction appear a certainty, but actual experience is lacking and therefore its future cannot be predicted with absolute certainty.

The Application of Electric Welding to Ship Construction

BY H. JASPER COX

This paper will be published in the January issue.

Hog Island—The Greatest Shipyard in the World

BY W. N. BLOOD, JR.

This paper appears in full on pages 678 to 690.

Letters from Marine Engineers

Discussion of the Design and Handling of Marine Engines, Boilers and Auxiliaries—Breakdowns at Sea and Repairs

This department is open to all readers of the magazine for the discussion of affairs in the engine room. All letters published are paid for at regular rates. Your ideas or experiences will be mutually helpful and interesting to other engineers. Write your letter now.

Preserving Iron and Steel

The necessity for and the economy resulting from the protection of iron and steel by the application of proper inhibitive paint coatings has already been so well established that there is no longer need for argument. Those who have to carry out this work recognize that it is very necessary to have the proper paint. A large amount of information has been collected during the past ten years showing the results obtained by actual tests upon materials. There are certain paints and materials that accelerate corrosion. The use of these should be avoided. Other materials possess inhibitive properties, and their contact with the bare iron is actually desirable, since they retard rust. The tests relate chiefly to the priming coat—the coat which comes in direct contact with the bare iron or steel. In view of the fact that the base is limited to linseed oil, drier and a volatile consisting either of turpentine or mineral spirits, or both, the pigments available for this class of work require careful consideration. The pigment composition for succeeding coats is not quite so important and may vary according to the color desired. As a matter of fact, for finish work a paint that is satisfactory on wood surfaces will be equally satisfactory when applied on iron and steel.

Economical practice would recommend the use of two paints—the first, a good priming coat paint, possessing the necessary inhibitive properties; the second, a good oil paint of the desired color for finish coat work.

When three coats are applied—experience has clearly demonstrated the economy of three coats on new work—the paint for the second coat may be made by mixing one gallon of priming coat paint and one gallon of finish, and reducing this mixture with one quart of turpentine. This paint will differ in color from the other paints, hence it will not be difficult for the painter to make sure that the whole surface has been properly covered.

The pigment, red-lead, has been used for many years in the priming coat of paint for iron and steel. It belongs to the class of pigments known as inhibitors. Among other pigments supplying this quality is the basic-lead chromate known as "American vermillion." This pigment has a value far in excess of red-lead or similar pigments. No doubt the cost of basic-lead chromate per pound compared with that of red-lead has been the cause for a lack of effort on the part of paint manufacturers to introduce its use. As a result, its merits are not fully known by the consumer. Basic-lead chromate also possesses inherent physical properties which make it in the end less costly than red-lead. It weighs only half as much as red-lead to the gallon and possesses better covering qualities than red-lead paint of similar consistency. The basic-lead paint will keep indefinitely in the can in ready-mixed form, whereas a straight red-lead paint will settle out quickly on standing. Red-lead in paste form has a tendency to harden in the container if it is kept standing for six or eight months, and frequently hardening develops in a much shorter period. Basic-lead chromate paint produces a uniformly satisfactory coating, and never sags or runs on perpendicular surfaces. It resembles the light shade of red-lead in color.

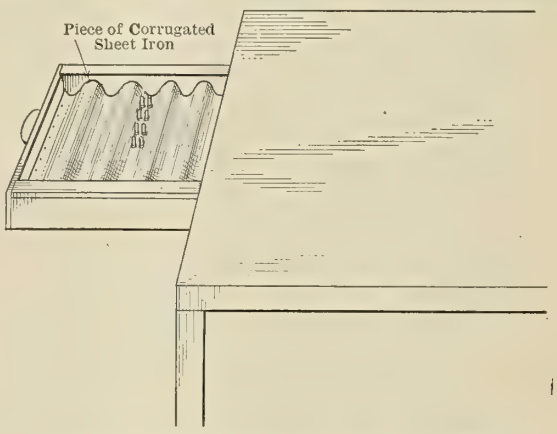
It is unnecessary to use basic-lead chromate straight. It may be extended by adding 25 percent of a chemically inactive pigment such as magnesium silicate, commonly known as "asbestine." A paint made from such a mixture has still hiding and spreading qualities equal to straight red-lead paint, and the inhibitive qualities are quite unimpaired.

A satisfactory basic-lead chromate should conform to the following specifications: (1) The pigment should consist of 25 percent basic-lead chromate and 25 percent inert pigment, such as asbestine. (2) The vehicle should consist of 90 percent pure linseed oil and 10 percent combined volatile and drier. (3) The paint should weigh 12½ pounds to the gallon. A paint complying with these requirements will give most satisfactory results.

Liverpool, England. MARK MEREDITH.

A Kink

During a recent visit to a small shop, I picked up this clever kink. The shop foreman, desiring to have several trays or separate small compartments in the various drawers of his small screw and pin cabinet, hit upon the



Handy Drawer Compartment for Small Ware

idea of using some sections of corrugated iron. The scheme is shown in the sketch, the sections of corrugated sheet iron being cut to fit the drawers, which provided many small trays or troughs that had no bothersome square corners or sides. C. H. WILLEY.

Proposed Method for Obtaining Fresh Water on Ships

One of the problems of marine installations is the supplying of sufficient fresh water for make up and drinking purposes. The only source of ship's supply aside from storage is the evaporator. There are, however, several drawbacks to the use of evaporators. In the first place they require fuel. They also need constant attention, since the temperature of the condensing apparatus must be closely regulated and the salt accumulation removed to secure satisfactory operation. Furthermore, it is difficult, if not impossible, to provide for evaporators on certain

types of ships—Diesel, for example—although this circumstance is not particularly important, since it is usually practical to store the water necessary for the trip on these ships.

Accordingly it has occurred to the writer that the amount of water formed as a product of combustion might in many cases be utilized to advantage. Bituminous coals are composed of from 30 to 40 percent of volatile material.

An average of 10 percent of this volatile material is hydrogen. Consequently, for every ton of coal burned approximately 150 gallons of water is formed.

For oil-burning ships, whether Diesel or steam, approximately one and one-half barrels of water is formed for every barrel of oil burned. As the average large steamship burns one to one and one-half barrels of oil per mile, there results the formation of from 300 to 500 barrels of water in the products of combustion. Diesel ships of the same capacity would form about one-third of this amount; thus 10,000 to 30,000 gallons of water per day are part of the products of combustion of a Diesel or a steamship, according to the type and size. This exceeds the capacity of the average evaporator.

While the products of combustion are of high temperature—that is to say, from 1,000 degrees in uneconomical plants, down to 500 degrees in very efficient plants—the heat mass is very small, and a comparatively small condenser would cool these products and extract the water. The installation of a comparatively small condensing apparatus in the top of the smokestack would not interfere with draft—because of the reduction in volume of the products of combustion—and would probably save 75 percent of the water of combustion.

If the exhaust from a Diesel engine were led to an ordinary small auxiliary condenser this apparatus would be sufficient to salvage practically all of the water of exhaust. Such a device would also incorporate the functions of a muffler by reducing the volume of the products of combustion. In fact, since this process is directly opposed to the expansion by heat, which causes the noise of exhaust, the apparatus would be the only muffler necessary.

It is possible that water thus produced would taste of fuel or lubricating oil. In all probability skimming and filtration would make it perfectly potable. If the fuel and lubrication of the engine were well adjusted, however, and the engine were in proper working order it would not be necessary for the water to become contaminated in the least. Furthermore, the condensation of the water could be controlled by long lines of separation, such as are used in refining various chemicals. So that the oils and other volatile hydrocarbons would be collected by a preliminary condenser maintained at a temperature of, say, 300 degrees, and the pure water vapor then recovered in another condenser maintained at the minimum temperature possible.

The water obtained by this method would be ample for all possible requirements of a ship, since the needs would be more or less proportional to the power of the engine. This would be particularly the case in a Diesel ship where no fresh water is required except for potable purposes.

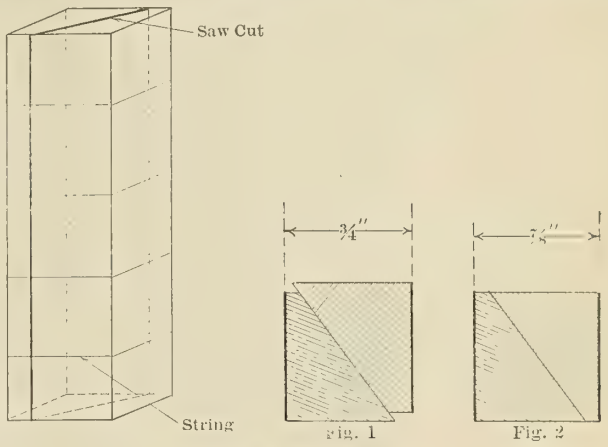
Oakland, Cal. COLE NEWMAN.

How to Keep Main Feed Pump Gland Tight

Main feed pumps that are worked off the engine pump levers are, as a rule, most unsatisfactory on account of the difficulty of keeping the glands tight and so permitting loss of feed water. Owing to this, many an engineer has been at his wits' end wondering what he would try next.

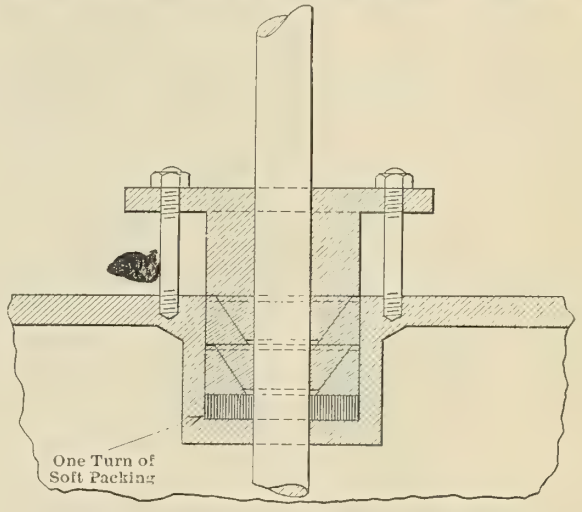
A remarkably efficient packing can be made with "square tuck's" canvas, rubber backed. If, for instance, the stuffing box requires a ¾-inch packing, order a ⅞-inch packing and proceed in the following manner:

Cut off the required length of packing, and, after gripping it in the vise, saw through, as shown, almost but not



Method of Cutting Packing

quite from corner to corner. With packing ⅛ inch larger than the stuffing box, it is better to put two saw blades together in the hacksaw. Having sawed the packing from end to end, tie the packing loosely with sewing twine or thin string, to allow it to enter the gland. When com-



Arrangement of Packing in Main Feed Pump

pressed by the gland, half the packing is wedged onto the rod, the other half against the stuffing box.

This type of soft packing has a much longer life than any of the other, owing to the fact that as it wears it can be nipped up again and again, until the wedge-like effect is destroyed. Figs. 1 and 2 in upper illustration show this.

Victoria, B. C. EDMUND B. DELL.

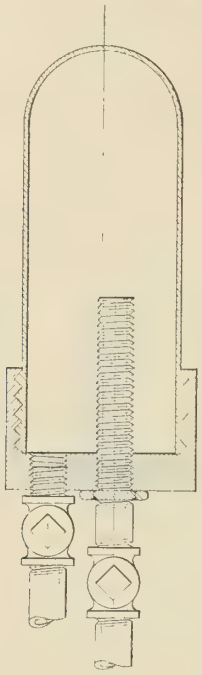
A Make-up Feed Telltale

The device, which is a make-up feed telltale, eliminates all guesswork connected with the amount of extra feed being used, and can be quickly constructed and affixed to any convenient place where it will be a constant reminder to the engineer on watch.

It is made of an old electric light watertight fixture. A by-pass may be inserted between the two pipes leading to and from the fixture, so that in the event of either of

the cocks becoming plugged up the device may be cleaned out without discontinuing the supply of feed.

The plug cock or valve on the line leading to the feed



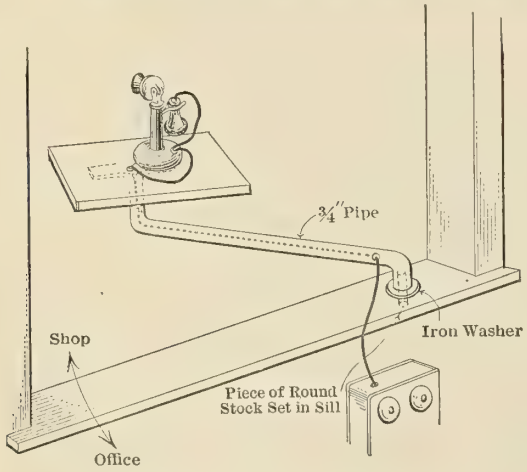
Section of Make-up Feed Telltale

manifold or tank is left wide open at all times, the amount of feed being regulated by the opening of the line leading to the condenser or air pump.

New York. J. G. K.,
Chief Engineer, S. S. *Drake*.

Telephone Swing Bracket

To enable the office desk phone to be used in both the office and shop, a novel stunt was employed by the foreman of a small shop. It is shown in the self-explanatory sketch. A piece of pipe, a board, and bit of round stock

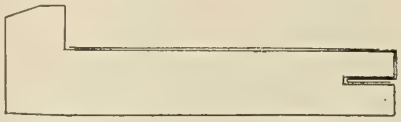


Swing Bracket for Supporting Telephone

are all that is needed. One end of the pipe is split and bent to Y-shape to hold the board. The other end is bent at 90 degrees and fits down over a piece of round stock set into the window sill. The phone cord runs inside the pipe, as shown. C.

Kink for Tightening Key

On several occasions the writer experienced difficulty in keeping some large keys tight in position, and as the material was not immediately at hand to make a larger key some alternative had to be found. We finally decided to use a strip of thin steel to supplement the thickness of



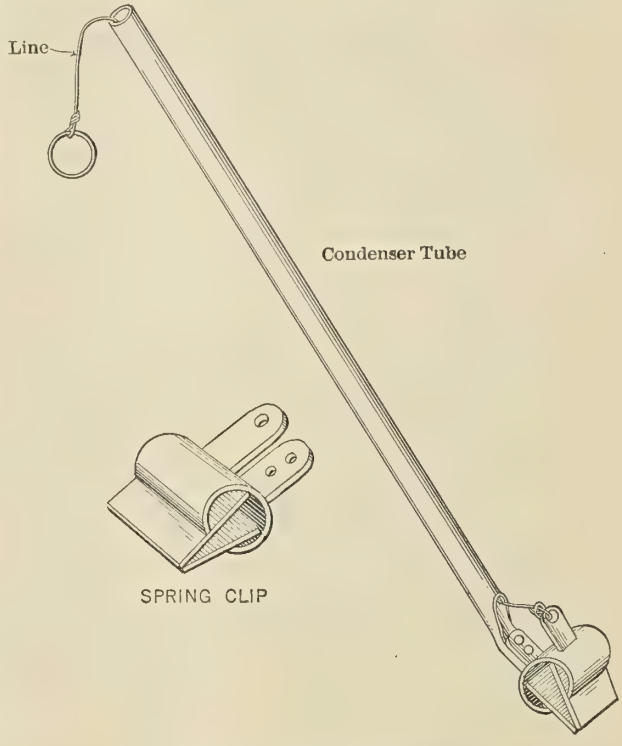
Filler Strip for Holding Key Tight

the key, inserting the filler as shown in the sketch, so that it would hold in position while the key was being driven. This strip of 1/32-inch steel driven in with the key in the manner shown proved to be the solution of the trouble, and no reports have yet been received that the job has come loose.

Philadelphia, Pa. W. A. LAILER.

Handy Pick-Up for Crank Pits

For recovering lost oil cans, cups and waste from the crank pits, a very handy device can be made from a length of condenser tubing and a large spring paper clip, as shown in the sketch. The paper clip is fastened to one end of the tubing by a couple of rivets, the end of the tube being split open and fastened for the purpose. A wire is passed through the tube, one end of it being secured to the handle of the paper clip, other end to a ring. To operate, the wire is pulled, opening the clip, with the clip end down in the pit. Upon releasing the wire the spring



Pick-up for Rescuing Lost Articles

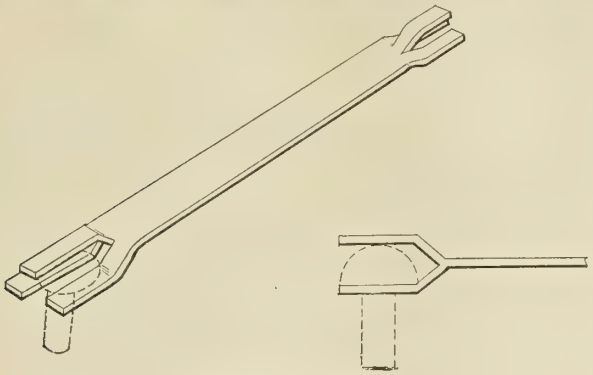
closes on the article and holds it. This enables the operator to draw up the article. The device ought to save its first cost many times over in the course of a year in "salvaged" material.

Concord, N. H. C. H. WILLEY.

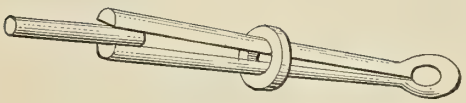
For Your Note Book

Here are two simple kinks that may be worthy of space in your note book. The writer himself found them so.

The rivet holder is made by splitting the end of a strip



Handy Rivet Holder

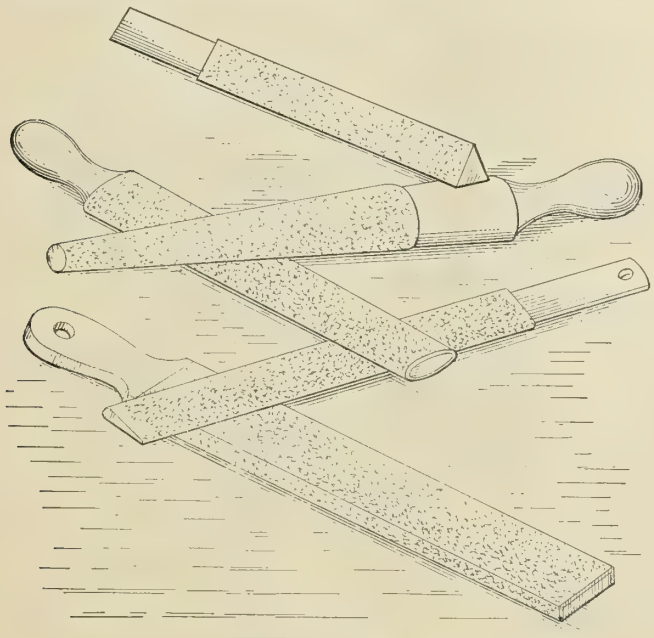


Handy Small Pin Holder

of band or strap iron in two places and then bending as indicated. The other kinks hardly need describing. A large cotter key and a washer provide a means of holding short, small pins while inserting them in valve rods of the ship's motor boat gas engine or other places. W.

Emery Cloth Sticks for Polishing Work

One of the oilers who cleaned the auxiliary machinery made up a set of emery cloth cleaning sticks for polishing

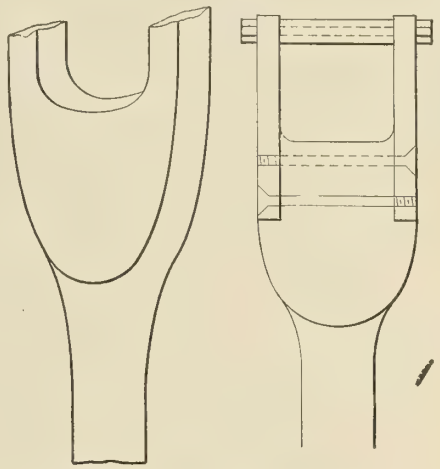


A Set of Emery Cloth Sticks

the sides of nuts, hooks and rocker shafts. The sticks are made of hard wood coated with fish glue, to which the emery cloth is applied, the various shapes permitting the work to be done very easily and neatly. Small tacks will hold quite as well as the glue, but the tacks will have to be sunk in so that the heads will not mar or scratch the work. H.

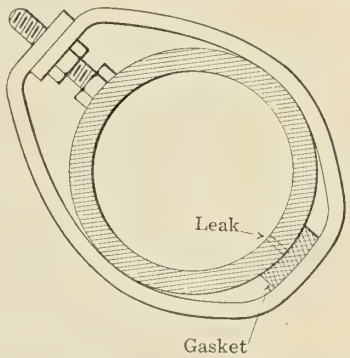
Handy Repairing Kinks

I am sending you herewith two kinks which I feel will be of interest. One shows a handy way of repairing broken shovel handles, and the other is an emergency



Repairs to Broken Shovel Handle

patch for pipe leaks. The broken wooden shovel handle was repaired as shown. The sides of the handle were planed down to a depth equal to the thickness of metal which was used in the repair job. Three-eighths to one-half-inch stock will serve. After being fitted to a handle, these are drilled and quartered, or ⅜-inch rivets set in and riveted over. The top of the metal parts also is drilled and an extension piece set in—preferably a piece of ¾-inch pipe and a bolt used to pull this fast. This makes a good serviceable top, and the new handle will probably outlast the metal plate in the shovel itself. The emergency patch on the pipe is nothing more or less than a bit of gasket placed over the leak and made secure by means



Emergency Patch for Pipe Leak

of a piece of flat metal bent around the pipe. In order to take up the slack on the gasket, a set screw is placed in the band opposite the leak and so screwed up as to make an effective job. This is a cheap arrangement, but serves in cases of emergency, as it has more than once in my own experience.

Concord, N. H. C. H. WILLEY.

Questions and Answers for Marine Engineers

Inquiries of General Interest Regarding Marine Engineering and Shipbuilding Will Be Answered in this Department

CONDUCTED BY "NAVAL ARCHITECT"

This department is maintained for the service of practical marine engineers, draftsmen and shipbuilders. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so.

There will appear in this column from time to time questions which have been asked by the Board of Steamboat Inspectors in the various examinations for engineers' licenses conducted by them. Such questions will be denoted by an asterisk (*) placed before the number if from examination for grade of chief, and by a dagger (†) if from examination for other grades.

Strength of Bracket

Q. (985).—Given a brace of flat steel bar, three inches wide and one inch thick, bent to form a brace as shown in the figure, fastened to a bulkhead by four rivets as shown, required the maximum load *W* and diameter of rivets. Give force diagram and reference in Merriman's "Strength of Materials," or some similar book.

A. (985).—The problem as outlined is not very practical, since the material is not distributed in such a manner as to produce the proper amount of strength, as will be shown in the following comment:

The method of tackling the proposition may be outlined thus: We may quite properly assume that the bar is hinged at points *A*, *B*, and *C*, Fig. 1, for the purpose of determining load *W*. This is not far from the actual conditions and, further, makes our calculations easier. It is

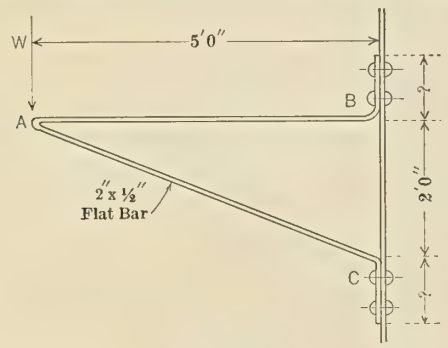


Fig. 1

clear from looking at the brace that with the weight acting downward, the member *AB* will be in tension and *AC* in compression. Now, if we weighted the bracket until it gave way, we should find that this occurred by the compression of *AC*, so that the strength of this member is the determining factor.

Now *AC* is virtually a column, pinned at the ends, and should be designed as such. Turning to page 291, Carnegie Pocket Companion (1917), it will be seen that the ratio of length to the radius of gyration, which is a measure of the stiffness of columns, should not be over 120 for members under constant stress. Now the radius of gyration is defined as

$$\sqrt{\frac{I}{A}}$$

where I is the moment of inertia about the axis through the center of gravity of section and A is the area of section. The axis would be the one giving the least radius of gyration. If we consider the proposed section, we have as radius of gyration =

$$\sqrt{\frac{\frac{bh^3}{12}}{bh}} = \sqrt{\frac{h^2}{12}} = \sqrt{\frac{(\frac{1}{2})^2}{12}} = .144 \text{ inch.}$$

The length of the member $AC = \sqrt{(60)^2 + (24)^2} = \sqrt{4{,}176} = 64.6$ inches. Hence

$$\frac{\text{Length of } AC}{\text{Radius of gyration}} = \frac{64.6}{.144} = 448,$$

a value much above the 120 shown to be permissible.

It is undoubtedly true that the bracket in Fig. 1 would bear some strain, but the metal is not well proportioned, consequently let us replace the present brace with one

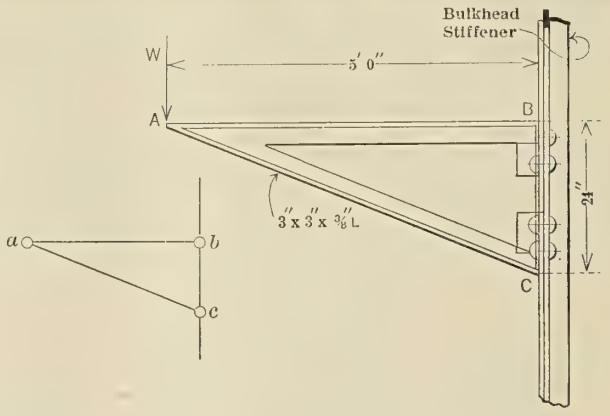


Fig. 2

made of 3-inch by 3-inch by ⅜-inch angle bar. It is true that this is much stiffer at points *A*, *B* and *C* than was the flat bar; we shall, however, still consider the frame jointed as suggested by *a b c*, Fig. 2, for sometimes the bar is not welded at points *B* and *C* as shown in Fig. 4; furthermore, the calculations are straightforward.

Our first step will be to find the maximum value of *W* which can be carried by our 3-inch by 3-inch by ⅜-inch angle. The member *AC* will be the determining feature. Its length is $\sqrt{(60)^2 + (24)^2} = 64.6$ inches.

The minimum radius of gyration for a 3-inch by 3-inch by ⅜-inch angle is .58 inch (Carnegie Pocket Companion, 1917. Page 185). The radius of gyration for practically all structural sections in common use has been worked out and tabulated as here seen.

The allowable stress in compression is

$$19{,}000 - 100\,\frac{L}{r} = 19{,}000 - 11{,}100 = 7{,}900 \text{ pounds per square inch.}$$

Since the area of this angle equals 2.11 square inches, for the allowable load on *AC* we have $7{,}900 \times 2.11 = 16{,}700$ pounds.

A consideration of the frame at *A* shows us that the member *AB* will exert a pull or tension and the member *AC* compression, which we may denote as F_1 and F_2 re-

spectively. This is shown in Fig. 3, which also illustrates the triangle of forces. Since this triangle is similar to *ABC*, Fig. 2, we may find by proportion W and F_1; F_2 being taken as = 16,700 pounds.

$$\frac{W}{F_2} = \frac{24}{64.6} \text{ or } W = \frac{24 \times 16{,}700}{64.6} = 6{,}200 \text{ pounds.}$$

$$\frac{F_1}{F_2} = \frac{60}{64.6} = F_1 = \frac{60 \times 16{,}700}{64.6} = 15{,}500 \text{ pounds.}$$

Should the angle be half cut away at *B*, we should have a stress of tension $= \frac{15{,}500}{3 \times \frac{3}{8}} = 13{,}800$ pounds per square inch, which insures us a factor of safety four to five. This is rather low for ship work, but corresponds fairly well with an allowable tension of 16,000 pounds per square inch, the

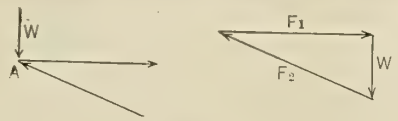


Fig. 3

limit designated by the American Bridge Company. In cases where W is not a fixed load, or where the failure would be dangerous, a factor of safety of 6 or more could be produced by reducing the value of W.

Of the fastenings to bulkheads, that at *B* is most vital, since here the rivets are in tension, which should be avoided as far as possible. Erecting and riveting is difficult where only one rivet is employed. The simplest method is to provide enough rivets to take by direct tension the force in arm *AB*. Using two ¾-inch rivets, we have for the stress (if borne equally by them)

$$\frac{15{,}500}{2 \times .442} = 17{,}500 \text{ pounds per square inch.}$$

As this is rather high, we had best place a clip between bracket and bulkhead, as shown in Fig. 4. Our rivet stress in tension will then be

$$\frac{15{,}500}{3 \times .442} = 11{,}700 \text{ pounds per square inch.}$$

The rivets at *C* are subjected to a shearing force. This will equal the component of force F_2 acting along the line

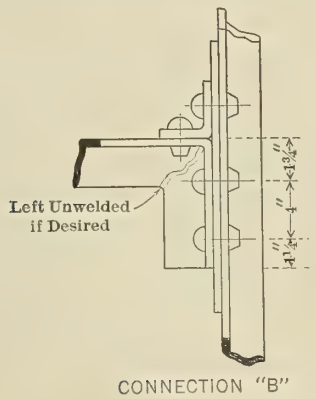


Fig. 4

BC, and will be found equal to W. Since the shearing area (sectional area) of a ¾-inch rivet is .442 square inch, the shearing stress is

$$\frac{W}{2 \times .442} = \frac{6{,}200}{2 \times .442} = 7{,}020 \text{ pounds per square inch,}$$

a value which is sufficiently low. Fig. 4 indicates proposed dimensions for riveting to bulkhead at *B*.

In the case of this bracket, it should be noted that a better design would be obtained by making *BC* more than 24 inches; also, it is to be seen that side strain is not provided for in the example submitted. In the analysis of the problem, we have taken the length of the different members along the heel of the angle instead of along the neutral axis. Fuller and Johnston's "Applied Mechanics," Vol. I, pages 16-26, will be found to include a somewhat similar problem.

NEW BOOKS

SHIP CONSTRUCTION AND CALCULATIONS. By George Nicol. Size, 6¾ by 9 inches. Pages, 502. Numerous illustrations. Glasgow, 1918: James Brown & Son. Price, 21s.

To all men of the merchant marine a more or less intimate knowledge of naval architecture is essential. To the officer mariner the subject may now be said to be a compulsory one, in that those who wish to qualify for the certificate of extra master must pass an examination in it. Besides this, there are other good reasons why an officer should have something regarding the construction and theory of ships. For instance, it would enable him, if called upon, to act as inspector on behalf of his employers at the building of a new vessel or the repair of an old. "Ship Construction and Calculations" is a book which contains fourteen chapters which are given over to ship calculations, moments, centers of gravity and buoyancy, details of construction, sheering forces, stresses and strains. Embraced in its table of contents is a chapter devoted to types of cargo steamers, another to the equilibrium of floating bodies, metacentric stability and the like. The type is agreeably large and the binding, which is of full cloth, makes a very presentable volume. The subject is well handled, not being too technically written, and yet containing sufficient formula to make it of value to the marine engineer. It is liberally illustrated with curves and charts, amidship sections of vessels, and takes up every phase of ship construction. The book is a really well-worth while addition to marine engineering literature.

New Records in Speeding Up Ship Machinery Production

Hardly a day passes in the Essington Works at South Philadelphia that some one of the many departments does not make a new record in the production of ship propelling machinery. Although the factory has not yet been completed a year, and will not be able to operate at full capacity for some time to come, in production, the shops are already ahead of their schedule. Handicapped by lack of labor, the company has even commenced to operate part of the blading section in the turbine department by women; other women, engaged for the steel metal working department, are turning out sheet steel boxes and lockers as the men used to do.

It is officially stated that the press crew in the forge shop, consisting of twelve men working on the 1,000-ton hydraulic press, increased its output from 83,000 pounds on Monday of last week to the maximum record for Friday of 105,000 pounds. This crew produces steel forgings for turbine and reduction gear axles, for ship propeller shafting and tail shafting. In the foundry the average output per day now amounts approximately to about 300,000 pounds of gray iron.

Shipbuilding and General Marine News

Contracts for New Ships—Shipyard Improvements—Engineering Projects—Improved Appliances—Personal Items

NEW SHIPYARDS AND EXTENSIONS OF EXISTING YARDS

Additions, Improvements and Orders for New Equipment

The Delano Shipbuilding Co. has been organized in Delano, N. J., by Walter D. Prouse, Henry F. Miller and Andrew H. Haig.

The Anchor Shipbuilding Corporation has been organized at Washburn, Wis., and has acquired a 125-acre site at Chequamegon Bay. Wildmar B. Nicolysen, Duluth, Minn., is president and general manager.

The Federal Dry Dock & Repair Co., Hoboken, N. J., has been organized by Wm. W. Corlett, Kenneth B. Halstead and Edward F. Briggs, Hoboken.

The Clark Martin Shipbuilding Co. has been organized by G. W. Clark and A. M. & M. H. Salzer, 925 St. Marks avenue, Brooklyn, N. Y.

It is reported that the Manitowoc Shipbuilding Co., Manitowoc, Wis., will add a complete foundry unit to its plant, at a cost of about $150,000.

The National Shipbuilding Co., Orange, Tex., will build a plant at Galveston for the purpose of equipping the wooden ships constructed at its yard.

The Northport Shipbuilding Corporation has been incorporated by T. J. Fallon, M. S. Reeves and R. Burk, 1482 Broadway, New York.

The Newbern Shipbuilding Co. has been organized by J. F. Rhodes, W. F. Aberly, F. G. Heyman, George S. Bennett, and L. I. Moore, all of Newbern, N. C.

The Connecticut Ship & Construction Co. has been organized by Frank H. Andrews, Albert H. Powers and Matthew A. Reynolds, New Haven, Conn.

The Rockport Shipbuilding Co. has been organized by E. M. Leavitt, E. McLean and D. L. Fogg, all of Augusta, Maine.

The Watercraft Construction Co. has been incorporated by A. Lennon, F. B. Wood and W. J. Doyle, 233 Broadway, New York.

The Union Shipbuilding Co., Fairfield, Md., has given a contract to Hughes Foulkrod Company, 1201 Chestnut street, Philadelphia, to erect ten ship ways and additional buildings.

The Langell Shipbuilding Corporation has been organized at St. Clair, Mich. The president is Gus Hill and the vice-president, Daniel E. Lynn, both of Port Huron, Mich.

The Ambursen Construction Co., 61 Broadway, New York, will establish a shipyard at Little Ferry, near Hackensack N. J., for the manufacture of concrete vessels for the Government.

The Honolulu, T. H., Chamber of Commerce has endorsed a plan to spend $9,000,000 for the improvement and extension of Honolulu's harbor.

The City of Natchez, Miss., W. G. Benbrook, Mayor, is planning to build terminal facilities, including docks, etc.

Secretary of the Navy Daniels is reported to have promised Mayor Peters, of Boston, Mass., that besides the prompt completion of the Massachusetts dry dock, the Federal Government will immediately begin work on the construction of several piers on the South Boston flats, which the national authorities are taking over, now that both branches of Congress have passed the bill.

The Bureau of Yards & Docks, Navy Department, Washington, D. C., is having plans prepared for a pattern shop in the League Island Navy Yard, Philadelphia, to cost more than $500,000.

The Swedish Government is reported to have ordered the building of a new dry dock at Beckholmen, near Stockholm, capable of docking a steamship of 10,000 tons.

The Pacific Coast Shipbuilding Co., Suisun, Cal., is understood to be arranging for a stock issue of $1,000,000 for proposed extensions and improvements. The plant has a 200-acre frontage on Suisun Bay and has an annual capacity of about 100,000 tons.

L. H. Rogers, 15 Broad street, New York, states that he is representative of the Concrete Ship Corporation, a Delaware concern, capitalized at $2,000,000.

The Buffalo Dry Dock Company, Ganson street and the Buffalo River, is building an addition to its punch shop to cost $20,000.

The San Diego Shipbuilding & Dry Dock Company, San Diego, Cal., is negotiating for property on the tidelands, between Front and Sixth streets, as a site for a new plant. The proposed works will cost about $100,000 for initial installation, and will be devoted to the production of steel and wooden vessels. Adam Weckler is vice-president and general manager.

The Todd Shipbuilding Corporation, 15 Whitehall street, New York, with yards at Brooklyn and Hoboken, is having a new 10,000-ton drydock constructed at the shipyard of Harry Cossey, foot of Henry street, Tottenville, Staten Island, N. Y. It will be built in four sections, each 90 feet long, 114 feet wide and 45 feet high. Extensions are being made at the Cossey yard to increase the capacity. Property on the north side of the yard is being filled in to allow for expansion.

The Todd Dry Docks, Inc., Seattle, has completed plans for a two-story pipe shop and mold loft, 34 by 100 feet, to cost about $5,000.

Construction has begun on a new one-story machine shop for the Southwestern Shipbuilding Company, East San Pedro, Los Angeles, as an extension to the present shop.

PROGRAMMES FOR SHIPBUILDING IN FOREIGN NATIONS

Further Shipbuilding Projects in Sweden

A large shipping company is being formed, it is announced, at Bergen, Norway, with a capital of 12,500,000 kroner, of which 6,500,000 kroner has been subscribed privately. The company, which will be named Britannia, with registered office at Bergen, will be managed by the shipowners, Otto Andersen and Mr. Christiansen. The subscribers, who include a number of the most prominent shipowners and business men of Bergen, have secured for the company five English post-war contracts for a total amount of $6,650,000, or an average price of $132.50 per ton deadweight. The vessels have been contracted for on the usual English sliding scale basis, based on prices in England in the autumn of 1917. The five vessels have the following deadweight tonnage: 8,400, 9,250, 10,800, 10,800 and 10,800 and are of the closed shelter-deck type.

English Shipbuilding Developments

Two large new berths have been constructed at the shipyard of the Northumberland Shipbuilding Company, Howdon. The scheme involved the construction of a new river frontage of piling and the reclamation of the land behind. Full possession of the site was only obtained on April 11, but the work was so well organized that the keel of the first vessel was laid on April 18, and the second keel on July 16. Both vessels will be launched before the end of the year. About 120 men each day and sixty each night were employed, as well as a number of women, who acted as ordinary laborers. The berths are 460 feet in length, are constructed of reinforced concrete, and can be used for the building of the heaviest type of vessel. One feature of the equipment is two steel gantries, each 60 feet in height, constructed on pipe foundations, which carry electric traveling cranes between the berths. The work involved the excavation of some 20,000 tons of earth, the driving of between 600 and 700 piles of steel and timber, the construction of 300 cubic yards of reinforced concrete and the erection of 300 tons of steel work.

Post-War Trade Anticipated

Norway, Sweden and Denmark are taking steps, as are other countries, to improve their principal harbors, largely with a view to dealing more actively with German competition when peace is signed. In this connection special men-

tion is made of Malmo, Stockholm, Gothenburg and Copenhagen, more than one of which will probably be considerably enlarged and established as free ports. Already the Norwegian Government has decided upon extensive developments as the result of a comprehensive report presented by a special commission. This programme will, it is believed, meet the increased requirements of the national shipping interests, and thus assist in making the country independent of transit trade by way of Great Britain and Germany.

Advices from Copenhagen also state that a Swedish shipping concern has applied to the Swedish Government for an advance of 2,000,000 kroner out of the funds for loans to shipping. This company intends, it is stated, as soon as the present difficulties attending navigation are removed, to establish a number of lines having as their terminals, Hamburg, Cologne, Riga, Amsterdam, Antwerp, Rouen, Bordeaux, London and certain other foreign ports which remain to be determined. The starting of a service to the Mediterranean, as well as lines between Finnish and Russian ports, are likewise projected.

Canadian Merchant Marine Plans

The Dominion Government is to build ten large steel steamers in British Columbia shipyards, the value of the contracts approximating $16,000,000. The firms securing contracts are: J. Coughlan & Sons, four steamers, 10,000 each, at Vancouver; Wallace Shipyards, four steamers, 8,100 tons each, at North Vancouver; Victoria Machinery Depot, two steamers, 8,100 tons each, at Victoria.

Some months ago the Dominion Government announced that it would take full charge of all steel shipbuilding in Canada, and among the first orders placed were some with the Wallace Shipyards. The big Coughlan yard was engaged on orders for Chambers & Co., of Liverpool, and Raeburn & Verel, of Glasgow, and will be busy on these contracts until January.

The first vessels, two steel steamers of 8,100 tons, will probably be ready to be launched by Christmas. As fast as present British orders are being filled the Canadian yards are being worked to capacity on Dominion-owned vessels. It is planned to have the Government-owned steamers distinctly named, the word "Canadian" forming part of each name. Canada will have a distinctive Canadian mercantile marine flag for the Government-owned ships. A design has been approved and will be authorized for use shortly. It will be the regular British Union Jack, but with an anchor and beaver on the ensign. The new flag will likely be floated first on the Government steel vessels which are now being constructed.

Concrete Shipbuilding at Christiansand

The Sorlandske Staalbeton Skibsbyggeri A. S., at Vanse, near Farsund, in the Christiansand district, has just launched its first concrete boat, a 250-ton lighter, and has on its docks a second vessel of similar dimensions ready to be launched. The company has also under construction a 600-ton vessel, which will be equipped with a 320-horsepower Bolinder engine, and a 1,000-ton vessel, to be equipped with a 360-horsepower Diesel motor. These vessels are all for the Nordisk Export & Import Company. The shipyard is favorably located and in close touch with the Listied Canal, now in process of completion. It controls patents for a type of vessel to be used as salting houses. These vessels are intended to follow fishing fleets to their places of catch, and there be used for the immediate salting down of the fish in basins along both sides of the vessel, the salt reservoirs being in midships between these basins.

Delaware Shipyards Seeking Contracts

Privately owned shipyards along the Delaware River are seeking contracts for ships abroad as well as from firms in this country. Many ships must be built and the Delaware River shipyards are prepared, it is said, to turn out ships in any number. No more attempts will be made at record-breaking, but the men will be asked to do a full day's work in eight hours. It is claimed the Pusey & Jones Shipyards will no doubt receive many of the contracts for rebuilding the Norwegian merchant marine, as the company is a Norwegian organization. As soon as the Government releases control of the two plants the Pennsylvania yards will begin building 12,000-ton ships and the New Jersey yard 5,000-ton ships.

Work at the Davis Shipyard

The hull shown in the illustration, which was launched by M. M. Davis & Son, at Solomons, Md., on October 12, is of oak and yellow pine, 133 feet length over all; 125 feet length between perpendiculars; 29 feet beam and 15 feet depth. Two boilers of the single-end Scotch type are fitted. The boat will be propelled by a 1,000-horsepower triple expansion engine of the vertical inverted surface condensing type, having cylinders 18 inches, 28 inches and 45 inches in diameter by 30 inches stroke, and with the built-in type of condenser, the engine being built by the Bay State Iron Works Corporation of Erie, Pa.

The hull of the seagoing tugboat illustrated was recently built for the Bethlehem Steel Corporation, Sparrows Point, Md., and is the same as the first eight tugs which the company is now building for the Emergency Fleet Corporation, with the exception of slight changes in the superstructure.

Hull for U. S. Shipping Board

The Davis shipyard, which has six building ways and makes a specialty of tugs and barges, has built and launched up to date this year seventeen vessels, and has at the present time eight on the ways. This yard also has under contract for the Emergency Fleet Corporation twelve seagoing wooden tugboats, 150 feet long over all, to be furnished with the same propelling machinery as the first eight boats.

Japan Increases Pacific Service

Japanese services are being constantly increased. The Mitsu Bishi Kaisha is establishing new lines from Kobe to Singapore via Hongkong and Manila; from Amoy to Singapore by way of Hongkong, Bangkok and Indo-China ports; from Singapore to Borneo and the East Indies generally, and from Formosan ports to the Philippines by way of Hongkong.

Future extensions may be judged from a knowledge of recent shipbuilding developments. During the first half of the year Japanese yards launched sixty-five steamers of over 1,000 tons each, and having an aggregate tonnage of 193,417. This is 74,079 tons more than in the same period last year. The figures for the second half of this year will probably reach a tonnage of 200,000, or 400,000 in round numbers, for the year. If small boats are included the annual production will total 500,000 tons, which is considered remarkable when compared with the annual tonnage of 50,000 launched before the war. Up to the end of August last the Japanese Government had received this year as extraordinary revenue from marine insurance a sum of nearly 10,000,000 yen.

Built for Bethleham Steel Corporation by M. M. Davis & Son, Inc.

De Laval Method of Oil Reclamation

The De Laval Separator Company has recently perfected a machine for oil reclamation—especially for the saving of oil in steam-driven marine power plants.

As is well known in such plants, the bearings and, in the case of turbine-driven units, the reduction gears are lubricated with large quantities of oil flowing over the moving parts. Some of these bearings and parts are cooled by water circulation; others are cooled by oil circulation. In either case, it is inevitable that some of the water will find its way into the oil system. Another source of water in oil results from the sweating of oil storage tanks. The presence of water, especially of salt water, in machinery, has always caused trouble because of the rusting of the parts; its admission to bearings and other moving surfaces causes uneven lubrication, resulting in uneven and excessive wear. Naturally, the removal of this water is essential for satisfactory power plant operation.

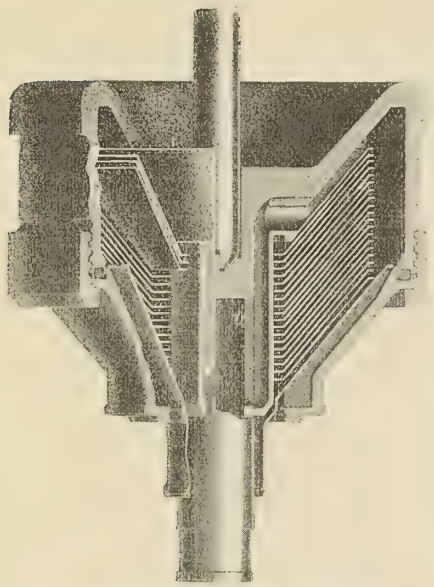


Fig. 1.—Sectional View of Purifier

The company claims that the De Laval method will remove not only all the water from the oil but also small particles of metal, dust and grit which come from the wearing surfaces and in various other ways are introduced into the oiling system. It will also eliminate core sand particles and pipe scale, which are particularly in evidence in new installations.

The oil purifier is installed between the overhead supply tanks and the drain tank, and so placed that it can be used to purify all or a portion of the oil. As installed the operator may clearly see the action of the purifier. Since the water and the oil are entirely separated, no matter how much or how little of each is present, the operator can notice the presence of water in the system by watching the discharge. The De Laval purifier will handle a large quantity of oil. It is positive in action and is not affected by the motion of the ship. The whole installation occupies less than two square feet of floor space. The company claims that after purification the used oil is as good as new; the dangers of a clogged oil system are thereby eliminated, and the factor of safety originally calculated by the designers maintained.

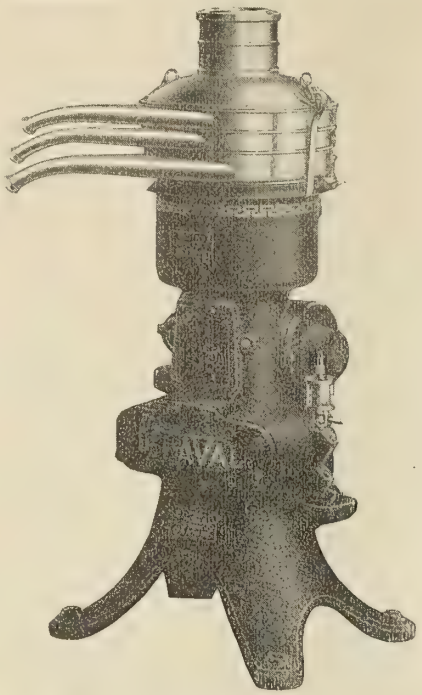


Fig. 2.—Steam-Driven Oil Purifier

The machine consists essentially of a cast iron frame provided with suitable bearings for supporting a vertical spindle which carries the purifying bowl at the upper end. The weight of the bowl and spindle, together with any thrust due to driving, is taken by two tread wheels, on which the polished end of the spindle rests. The bowl spindle is held in an upright position by a flexible spring-collar surrounding the upper bearing. The spring-collar permits a small amount of lateral motion and allows the rapidly revolving bowl to assume an unrestrained position. Surmounting the bowl are three covers, arranged to serve for overflow oil and water discharge, respectively. At the top of the overflow cover is located the regulating cover into which the oil to be purified flows. This cover is provided with a removable strainer to eliminate the larger particles of foreign matter from the oil before it reaches the bowl. The purifier is either motor-driven or steam-driven. The steam-driven type is here illustrated.

The capacity of the purifier is 300-350 gallons per hour. The weight for motor-driven style, 750 pounds net; turbine-driven style, 650 pounds net. The purifier is also made in a smaller size, either steam or motor driven. Capacity of the smaller size is 100 gallons per hour; the weight of the motor-driven type in this size is 390 pounds net; steam-driven purifier, 290 pounds net.

The arrangement of the rotating parts is clearly shown in Fig. 2. The worm screw is multiple threaded, having eight threads. The proportions are such that the speed ratio between the spindle and the worm wheel is about ten to one; that is, with a speed of 700 revolutions of the belt pulley the bowl will make 7,000 revolutions per minute.

When the bowl is revolving at the proper speed the oil to be purified enters the central tubular feed shaft and passes downward and out through slots into the channels in the distributor. From thence it passes through the holes in the bottom of the distributor to the disc separating space in the bowl. Here, due to centrifugal action, separation takes place. The material which is heavier than the water, such as sand and metallic particles, is thrown outward to the periphery of the bowl, and held there in the sediment pocket by centrifugal force. The water, being heavier than the oil, also passes outward and upward along the outer edge of the discs to the discharge outlet. The oil passes inward between the discs toward the central shaft, thence upward to the discharge outlet. Surrounding the outlets are the liquid cover and the sludge cover, so arranged that centrifugal force throws the liquids from the outlet openings into the covers, whence it is conducted to the proper receptacles by the attached spouts. If at any time the bowl should become clogged by a large amount of dirt, so that the liquid could no longer flow through, the inlet tube would fill up and overflow. By using a third cover the overflow is kept separate and acts as a warning signal that the bowl needs cleaning. The action of this oil purifier in marine installations keeps the oiling system free from water and solid material, thereby insuring longer life of the bearings and other wearing surfaces, and greatly reducing the liability of burned-out bearings and other destruction.

Alternating-Current Arc Welding Machine

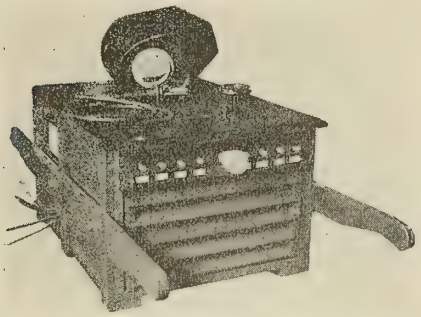
As is well known, electric arc welding, cutting and repairing is accomplished by the application of the heat occurring when the electric current jumps a gap in its circuit. Heretofore the apparatus available for this purpose has employed direct current at the arc which, in the case of either an *A-C* or *D-C* power supply, required a heavy motor generator set and an elaborate switchboard. For general weldings this means a 10- to 15-horsepower motor, and 8- to 10-kilowatt generator, with switchboards for both. With starting apparatus, the whole set weighs from one to two tons.

A new method for holding and controlling an alternating-current arc has just been introduced by the Electric Arc Cutting & Welding Company, Newark, N. J. They are now putting on the market a lightweight A-C welding machine consisting of a special transformer with no moving parts which will last indefinitely, the company claims, and do all that the D-C machines accomplish and a great deal more.

A few features of this new machine merit emphasis. Some D-C machines strive for constant volts and some for constant current, but it is one of nature's laws that the heat in the arc is the product of both the current and the voltage across it, which is synonymous with energy, and hence heat. The ideal condition is the constant product of current and volts. The company holds that their A-C machine does hold the heat of the arc automatically and substantially constant for any given setting.

Any experienced operator can weld from almost any source of D-C power supply, if he is provided with the means of holding the current substantially constant, as his steady, practiced hand will

hold constant voltage across the arc, and hence approximately, constant heat. It is this feature, the absolute necessity for skilled operators, which has held the electric arc back. The A-C machine, without moving parts, easily holds this arc wattage without special skill on the operator's part. Hence heat is substantially constant for any given setting. As soon as the operator becomes accustomed to the sound and sight of the arc, and can deposit the molten metal where he desires, the company claims it is absolutely impossible for him to burn the metal from too much heat or to make imperfectly joined, or "cold shot" welds from too little heat. Of course, different metals, electrodes and conditions in shops require various amounts of heat and varying temperatures. These adjustments are obtained by an easily adjusted handle on the special transformer with taps arranged on the plugging board. The transformer is 80 to 90 percent efficient, the company holds. This high standard of welding efficiency is possible because but one simple change is made in the energy, and hence only one loss is added to the essential heat required to melt a pound of metal.



Electric Arc Cutting and Welding Machine

Due to the weight of D-C machines with their motor generator and switchboards, base and starting apparatus, there really is no D-C portable type. This new A-C machine, however, in its largest 60-cycle type, weighs about 200 pounds. There are means provided for two men to carry the apparatus to any location, where it may be set up on a bench, or under the bench, or in any position relative or remote from the work. Since the machine has no continually moving parts it will operate in any position, either upside down or on its side.

The machine is designed to meet any power supply. For safety's sake, however, it is not good practice to introduce in the shop any machine with more than 650 volts on the primary. This lowering of the shop voltage is standard practice. The machines can be made for single-phase, two-phase three wire, two-phase four wire, or to operate across the outside wires of the two-phase system, or from a three-phase power supply. The polyphase is necessarily 30 percent heavier than the single-phase machine. For welding, a kilowatt power demand of from 3 to 4½ kilowatts is made; for cutting from 6 to 8 kilowatts. In the case of the two-phase machine, balanced current can be drawn from each of the two phases, by placing the machine across the outside wires, *i. e.*, the 312 volts of a 220-volt circuit.

The wiring is very simple with this new system. The distribution wiring is on the high voltage side, and requires but ordinary wire sizes. For a 400-volt shop, two No. 8 wires are all that are necessary to reach any welding location with a simple plugging-in arrangement. Maintenance is easy because of the absence of moving parts.

The company claims that the qualities inherent in the A-C arc make the cutting of cast iron entirely satisfactory, causing molecular penetration of from ¼ to ⅜ inch, and so distributing the weld and the cast iron that there is no definite hard layer, except for the very outer edges. The surface resulting from the deposition of the metal is smooth. With certain electrodes, ductility and elongation obtained by this new method equal that of mild steel. With boiler plate, test pieces can be welded which will bend flat on themselves, the bend being in the weld. In the twisting test two complete revolutions are possible before tearing.

This new A-C system can be used for either cutting or welding, or both, in one machine. The portability and adaptability of the apparatus should make it particularly valuable for ship construction and repair work.

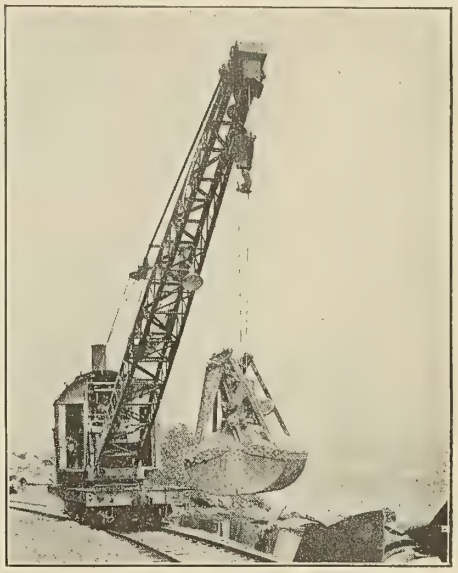
"Blaw" Single-Line Bucket for Coaling Ships

In line with the increased effort to secure efficient handling of coal and cargo at ports and terminals, the placing on the market of the new Blaw-Knox single-line bucket of the clam-shell type is opportune. This device is a simple rope reeved bucket, entirely free from latches, catches and other sliding parts, with a folding arm that locks itself by position only. The locking is absolutely positive, and the bucket cannot possibly open and dump its load, the manufacturers claim, until the arms are pushed over by the operator.

Since the bucket may be hooked on and off the block of any type of crane or derrick with as much ease as a "sling" or other appliance, the equipment is left free for other work when the bucket is not in use. When operating from overhead cranes, these buckets may be used for loading and unloading coal, completely eliminating hand-loaded coal tubs, without installing additional drums or winches; on stiff leg, guy or traveling derricks rehandling of material is possible.

The position of the bucket closed and loaded is shown in the accompanying illustration. It may be dumped by the pull of the operator upon a hand line attached to the tripping lever. This lever is arranged to be operated from the crane cab. It may, however, be operated from the ground if preferred. The complete load may, on the other hand, be dumped without the use of tripping lever or hand line. This action is accomplished by lowering the loaded bucket onto the pile or at the place where the material is to be deposited and slackening the line. Thereupon, the folding arms fall over of their own accord, exactly as if they had been pushed over by a tripping lever. Subsequently, when the bucket is hoisted, the scoops open out and the material is gently deposited. By this arrangement the dumping operation is practically automatic.

The dumping shock is taken up within the bucket itself. The opening motion is arrested by reaction on the line, owing to the position at which the end is secured to the back of the scoops. The shock absorption is complete, and there is no jar on any of the bucket parts; in



Blaw-Knox Single-Line Bucket

fact, the buffers on the hinges do not quite come together until after the bucket is set down again.

This bucket is usually operated with guide rolls in its head—whenever the overhead crane is high enough to get the necessary clearance. It is also employed whenever the bucket is reeved directly to the hoisting drum. Where the clearance is insufficient for operation in this way the guide roll may be dispensed with, as shown in the illustration. The hook is thereby allowed to descend to a point below the head of the bucket. The makers of this new loading device are the Blaw-Knox Company, Pittsburgh, Pa.

Launching Under Unusual Auspices

When the 8,800-ton ship *West Eldara* went down the ways at Skinner & Eddy plant, No. 2, on October 14, Prince Axel of Denmark and his staff were the guests of honor. The boat was christened by a former classmate of the member of the Danish royal family, Mrs. Hakon H. Hammer, wife of the president and general manager of the Universal Shipping Trading Company.

Prince Axel arrived in Seattle but two days previously to the launching. The last details were immediately arranged in his honor. When he mounted the launching platform, the Skinner & Eddy band played the national anthem of Denmark, a tribute, since the workers had mastered the notes over night and played without music.

Ships Loaded in Midstream

Owing to the stress of the times the practice of loading vessels in midstream on the Hudson, or in the harbor, has become quite frequent of late. The unusual sight is now often seen on the Hudson of a large tramp loading direct from a carfloat.

Shipyard Notes

The American Shipbuilding Company, Cleveland, Ohio, is building steel freight ships at Buffalo. Four vessels are now under construction there.

The Charles Ward Engineering Works, Charleston, W. V., will build two tunnel screw towboats and the Marietta Manufacturing Company, Point Pleasant, Ohio, will build two tunnel screw towboats and two stern wheel towboats.

The Patterson-McDonald Shipbuilding Company, Seattle, Wash., is building ten wooden steamships for the Australian Government.

The Wallace Shipbuilding Company, Vancouver, B. C., has received a contract from the Dominion Government to build two steamships of 5,000 tons' capacity and one of 4,300 tons.

The Kingston Steamship Company, Kingston, Ont., will build a 3,750-ton ship for the Dominion Government.

The Port Arthur Shipbuilding Company, Port Arthur, Ont., will build two 3,400-ton steamships for the Dominion Government.

The Victoria Machinery Depot, Victoria, B. C., has received a contract to build two 8,100-ton steel vessels and has been advised that it will receive orders to keep it in operation for at least three years.

Detroit shipyards, employing 8,000 men, have contracts for nearly two years ahead which will be filled, according to officials of both the Great Lakes Engineering Works and the Detroit Shipbuilding Company. The tractor plant of Ford & Son, Dearborn, Mich., has orders for 20,000 tractors on its books, and will take over the $1,000,000 plant built by the Government to increase its production. About 3,000 men will be employed.

The close of the war will bring no abatement in activities at the shipbuilding plant of the New York Shipbuilding Company, Camden, N. J. The company has contracts on hand to keep the plant operating at full capacity on Government vessels, as well as merchant ships for a few years to come. The new yard of the company, now being completed at a cost of about $10,000,000, will be carried out as originally planned, and is expected to be ready for service shortly after the first of the year. This section of the works will give employment to about 4,000 men. Thirteen vessels and eighteen torpedo boats are now on the ways. Two transports also are being constructed. Plans have been prepared for the erection of two one-story additions, 64 by 160 feet and 78 by 90 feet.

Additional buildings are being added to the equipment of the Grant Smith-Porter Shipyards at Aberdeen, Wash. Two steamers of the second contract of eight Ferris types have been completed, and they will be launched in a short time. Scarcity of calkers has delayed the completion of the steamers, which otherwise would have been ready a month ago.

The Welin Marine Equipment Company, 305 Vernon avenue, Long Island City, manufacturing motor boats and other small sea craft, has acquired about 50 by 50 feet adjoining its works for extensions. Plans have been filed for the erection of two additions at Vernon avenue and Hamilton street, to cost about $40,000. It is devoting its operations to the production of boats for the Government.

Government Ship Contracts

The United States Navy Department has asked Congress to authorize a second three-year building program, to provide ten additional super-dreadnaughts, six battle cruisers and 140 smaller vessels, at a cost of $600,000,000. This is in addition to the 156 vessels comprising the first three-year building program authorized in 1916, work on which has been delayed by the war, but which is to be resumed before next July.

The Dachel-Carter Boat Company, Benton Harbor, Mich., has received a Government order to build five ocean-going steel tugs, making necessary enlargements in its plant.

W. G. McAdoo, Director General of Railroads, Washington, D. C., has awarded contracts amounting to $6,170,000 for six towing steamers and forty steam barges, to be used on the Mississippi and Black Warrior Rivers. Four of the steamers are to be of the tunnel screw type, 200 feet long and 40 feet broad, with a draft of 6 feet, while the other two will be 256 feet long, 48 feet broad, with a draft of 10 feet. The barges will have a carrying capacity of 2,000 tons each.

The Hillsborough Shipbuilding Company, J. Wade Tucker, president, Tampa, Fla., will build four wooden barges of 2,500 tons each, for the United States Shipping Board Emergency Fleet Corporation.

The G. M. Standifer Shipbuilding Company, Portland, Ore., has received contracts from the United States Shipping Board Emergency Fleet Corporation to build five more steel steamships, of about 9,000 tons each.

The G. M. Standifer Construction Corporation, Vancouver, Wash., has received contracts from the United States Shipping Board Emergency Fleet Corporation for ten wooden steamships.

L. H. Shattuck, Inc., Portsmouth, N. H., a Government-owned plant, is building wooden ships of the Ferris type for the United States Emergency Fleet Corporation. Five steamers have already been launched. Twelve ways are under construction and six more are to be added.

The American Bridge Company, 30 Church street, New York, will build twenty-five of the barges and the Dravo Contracting Company, Pittsburgh, Pa., will build fifteen of the barges for the United States Railroad Administration, to be used on the Mississippi River.

PERSONAL

ERNEST E. JOHNSON, of the Pacific Steamship Company, sails for Vladivostok on December 15, to open up an office there. Military operations in Siberia have brought a great fillip to American shipping between the American Pacific coast and Vladivostok.

FRANK A. BROWNE, who has been with the Fleet Corporation since its beginning in April, 1917, has resigned his position as general purchasing officer to accept the management of the Mauer plant of the Barber Asphalt Company at Maurer, N. J.

E. V. FRAME, who has been connected with the Chicago office of the Judson Freight Forwarding Company, has assumed charge of the Seattle office of that company.

PROF. COMFORT A. ADAMS, chairman of the committee on electric welding of the Emergency Fleet Corporation, and president of the American Institute of Electrical Engineers, recently addressed the members of the Baltimore Section of the Institute and Engineers' Club on "Application of Electric Welding to Shipbuilding."

THOMAS A. CARR, work's manager of the American International Shipbuilding Corporation's plant at Hog Island, has tendered his resignation, to become effective December 1. Mr. Carr will return to the Boston office of Stone & Webster, to take an important part in new construction work in the near future.

E. G. EKSTROM, general manager, Schaw-Batcher Shipbuilding Company, San Francisco, has resigned and been succeeded by A. L. Becker, former general superintendent of the yards, who in turn is succeeded by O. B. Kibele, formerly marine superintendent of the Union Iron Works, San Francisco.

JOSEPH W. BROOKS and WILLIAM APPLEGARTH are the principal incorporators of the Davis Shipbuilding Company, Cambridge, Md., incorporated, with a capital of $104,000, to operate a local plant.

H. D. MEGARY has been elected to the office of secretary of the Chicago Pneumatic Tool Company since W. B. Seelig has resigned.

A. M. BROWN has been appointed district manager of sales of the Chicago Pneumatic Tool Company, 1740 Market street, Philadelphia, succeeding G. A. Barden, who remains in Philadelphia as sales representative for the company. For some time past Mr. Brown has been located in the New York offices of the company as assistant manager of the compressor sales division.

ROGER C. SULLIVAN was recently appointed a member of the board of directors of the Independent Pneumatic Tool Company. He was elected chairman of the board and a member of the executive committee to fill the vacancies caused by the death of the late John P. Hopkins.

NORMAN P. FARRAR, who for a number of years has been district manager of the Shepard Electric Crane & Hoist Company in Philadelphia territory, has opened a new office in the New Lexington building, Baltimore, Md.

OBITUARY

ALBERT BALLIN, general director of the Hamburg-American Steamship Company, died suddenly, November 9, in Berlin, at the age of 61 years. When the line was taken over by Mr. Ballin in 1887 it was only a small shipping company. Before the outbreak of the war it was accredited as being the greatest single steamship line in the world—500 vessels, with a tonnage built and building, of about 1,500,000, including the two greatest liners in the world, the *Vaterland* and the *Imperator*, in 1914.

CAPT. JEREMIAH B. GREGORY, a retired master mariner, died at Rockland, Me., a few days ago at the age of 85 years. He followed the sea for fifty-seven years, being master for a long time of the bark *Hanson Gregory*, which he lost off the Florida coast in 1870, with three of the crew. He was later superintendent of mining companies in Maine, and chief of police for five years in Hudson, Mass.